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CEX-59.4.14

CIVIL EFFECTS STUDY

AERORADIOACTIVITY SURVEY AND AREAL GEOLOGY OF PARTS OF EAST-CENTRAL NEW YORK AND WEST-CENTRAL NEW ENGLAND (ARMS-I)

Peter Popenoe

Issuance Date: October 1964

CIVIL EFFECTS TEST OPERATIONS

U.S. ATOMIC ENERGY COMMISSION

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USAEC Division of Technical Information Extension, Oak Ridge, Tennessee

AERORADIOACTIVITY SURVEY AND AREAL GEOLOGY OF PARTS OF EAST-CENTRAL NEW YORK AND WEST-CENTRAL NEW ENGLAND (ARMS-I)

By

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August 1962

ABSTRACT

An airborne gamma-radiation survey of Connecticut, Rhode Island, and parts of New York, Massachusetts, New Hampshire, and Vermont was made during the period from 1958 through 1960 by the U. S. Geological Survey in cooperation with the Division of Biology and Medicine, U. S. Atomic Energy Commission. Results of the survey indicate that a wide range of natural radioactivity exists and that the levels are closely related to the type of bedrock underlying glacial material, and subordinately to the glacial material. This report discusses the radioactivity and correlates the data with the areal geology of the northern portion of the area surveyed. The southern portion of the area is discussed in CEX-58.4.6[1].

The area was traversed with parallel flight lines flown 500 ft above the ground and spaced at 1-mile intervals. Continuous aeroradioactivity profiles were obtained with scintillation detection equipment installed in a twin-engine aircraft. A map of radioactivity units was prepared from the profiles.

Parts of four physiographic provinces are included in the survey area: the Appalachian Plateau province underlain by relatively flat-lying Paleozoic shale, sandstone, and limestone; the Valley and Ridge province underlain by weakly folded Paleozoic shale, sandstone, limestone, and dolomite; and the New England and Adirondack provinces, underlain chiefly by highly deformed Precambrian and Paleozoic schist, gneiss, and amphibolite. Bedrock in the survey area is mantled with unconsolidated glacial deposits that range in thickness from 0 to more than 200 ft.

Rocks of both sedimentary and igneous origin produced high and low levels of radioactivity. Three large areas containing rocks of moderate to high radioactivity are present: one is associated with clastic rocks of Devonian age in the Helderberg Plateau and foothills of the Catskill Mountains: another is associated with phyllite and slate of Cambrian and Ordovician age in the Taconic Mountains and foothills; and a third is associated with a broad belt of phyllite, micaceous quartzite, and intrusive igneous rock, chiefly of Devonian age, in New Hampshire and east-central Massachusetts. Low radioactivity is associated with a large massif of anorthosite in the Adirondack Mountains, large areas of the Precambrian complex of the Green and Adirondack Mountains, a broad belt of Cambrian, Ordovician, and Devonian schist, gneiss, and amphibolite in eastern Vermont; igneous rocks of the Oliverian Plutonic Series (Devonian?) in New Hampshire and Massachusetts, and glacial lacustrine deposits along the Hudson and Connecticut Rivers.

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AERORADIOACTIVITY SURVEY AND AREAL GEOLOGY OF PARTS OF EAST-CENTRAL NEW YORK AND WEST-CENTRAL NEW ENGLAND (ARMS-I)

1. INTRODUCTION

1.1 Location of Area

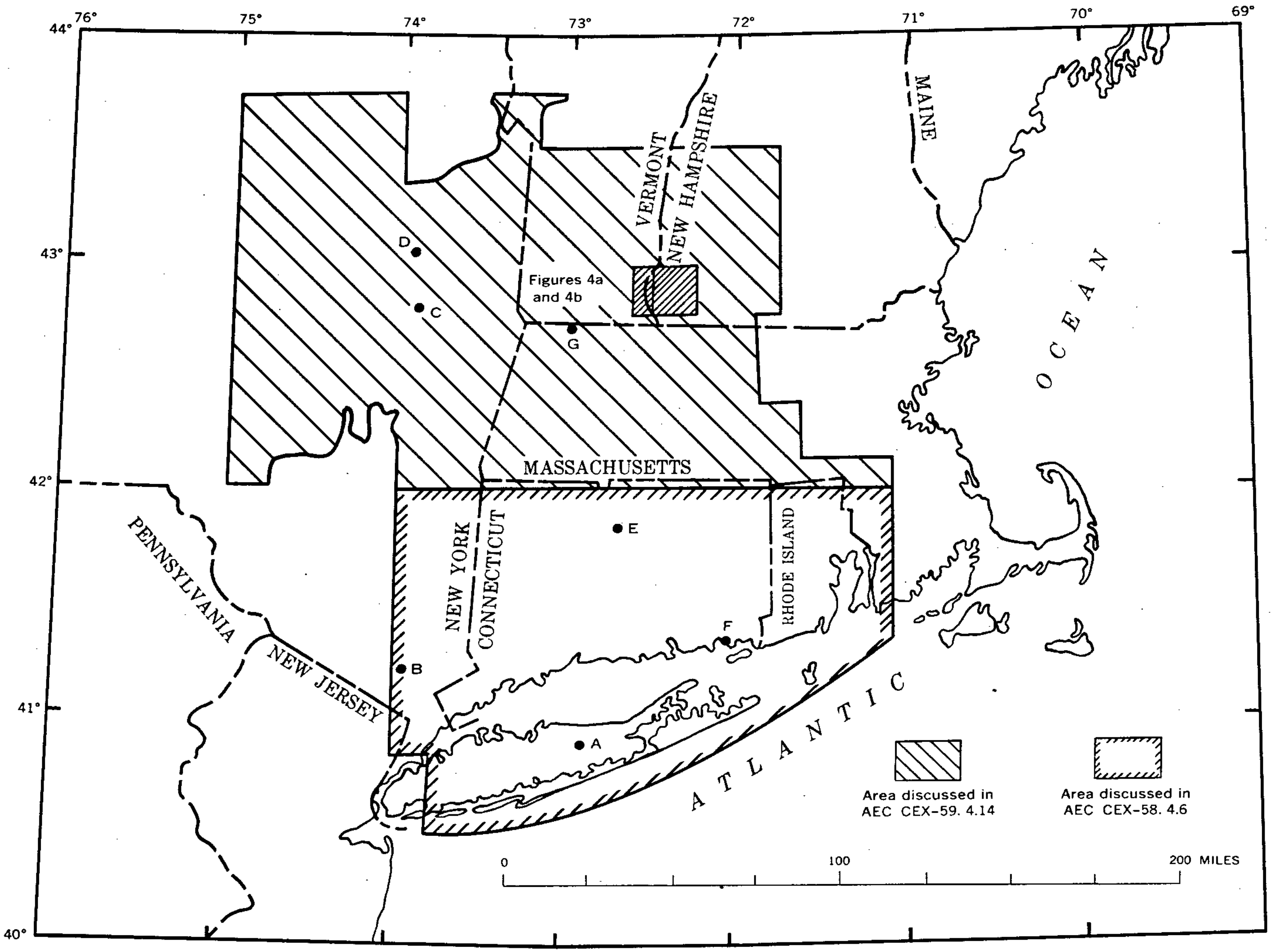
An aeroradioactivity survey of Connecticut, Rhode Island, central and western Massachusetts, eastern New York, and parts of southern Vermont and southwestern New Hampshire was made between Oct. 17, 1958, and Aug. 31, 1960, by the U. S. Geological Survey in cooperation with the Division of Biology and Medicine, U. S. Atomic Energy Commission, as part of the Aerial Radiological Measurement Surveys (ARMS-I) program. The surveyed area comprises about 28,000 square miles; however, only the northern part of the area is discussed in this report (Fig. 1). The southern part of the survey area is discussed in CEX-58.4.6[1].

1.2 Purpose of Survey

The survey is part of a nationwide program to obtain data on the existing gamma radioactivity for areas in and adjacent to nuclear facilities. These data provide information that can be used to detect any future variations in radioactivity which may result from nuclear testing, reactor or other Atomic Energy Commission operations, or radioactivity accidents.

The major nuclear facilities included within the surveyed area are: Brookhaven National Laboratory, Upton, N.Y.; Consolidated Edison Reactor, Indian Point, N. Y.; Knolls Atomic Power Laboratory, Schenectady, N. Y.; Submarine Intermediate Reactor (Mark A) West Milton, N. Y.; Combustion Engineering Facility, Windsor, Conn.; Electric Boat Works, Groton, Conn.; and Yankee Atomic Power Company, Rowe, Mass. (Fig. 1).

Information on radioactivity levels in the environs and outside the plant boundaries of Atomic Energy Commission and contractor installations are reported in special periodic reports from each installation. These reports are published in the U. S. Public Health



A—Brookhaven National Laboratory, Upton, New York
B—Consolidated Edison Reactor, Indian Point, New York
C—Knolls Atomic Power Laboratory, Schenectady, New York
D—Submarine Intermediate Reactor-Mark A, West Milton, New York
E—Combustion Engineering Facility, Windsor, Connecticut
F—Electric Boat Works, Groton, Connecticut
G—Yankee Atomic Power Company, Rowe, Massachusetts

Fig. 1—Location of the survey area and nuclear facilities within the area.

Service series titled "RADIOLOGICAL HEALTH DATA", issued monthly and available from the Government Printing Office, Washington, D. C.

The entire area surveyed includes the overlapping areas within 50 miles of the Rowe, Schenectady, Windsor, and Brookhaven facilities. Parts of the area could not be flown because of the rugged topography. These are labeled "not surveyed" on the radioactivity map (Pl. 1).

1.3 Airborne Survey Procedure

Radioactivity data were obtained with scintillation detection equipment installed in a DC-3 type aircraft. East-west flight lines were flown at 1-mile intervals in the entire area except the part west of Albany, N. Y., where the lines were oriented north-south. The aircraft maintained an approximate altitude of 500 ft above the ground at an average air speed of 150 mph. Topographic maps were used for pilot guidance. The flight path of the aircraft was recorded by a gyrostabilized continuous-strip-film camera, and the distance of the aircraft from the ground was measured by a continuously-recording radar altimeter. Fiducial markings which provide a common reference for the radioactivity and altimeter data and the strip film, were made with an electromechanical edgemark system operated by the flight observer when the aircraft passed over recognizable features on the ground[2].

1.4 Scintillation Detection Equipment

The gamma radiation detection equipment used by the Geological Survey was developed by the Health Physics Division of Oak Ridge National Laboratory and has been described in detail by Davis and Reinhardt[3]. Briefly, the detecting element consists of six thallium-activated sodium iodide crystals, 4 in. in diameter and 2 in. thick, each with a photomultiplier tube and connected in parallel. The signal from the detecting element is amplified and fed through a discriminator and pulse shaper that is set to accept only pulses originating from gamma radiation with energies greater than 50 thousand electron volts (kev). The signal is then fed to two rate meters. One rate meter feeds a circuit that records total radioactivity on a graphic milliammeter. The signal from the other rate meter is recorded by a circuit from which the cosmic background has been removed and which is approximately corrected for altitude variations from the nominal 500-ft surveying altitude by a signal from the radar altimeter servomechanism. The system described is illustrated by a diagram (Fig. 2).

The range of topographic roughness handled satisfactorily by the altitude compensator is approximately between 100 and 900 ft. The gamma absorption of a 1000-ft-thick air layer is great enough to make detection of all but the largest natural sources impractical[4], therefore a large percentage of the measured signal when the aircraft is more than 900 ft above the ground is supplied by the altitude compensator. The compensator on the Geological Survey equipment was

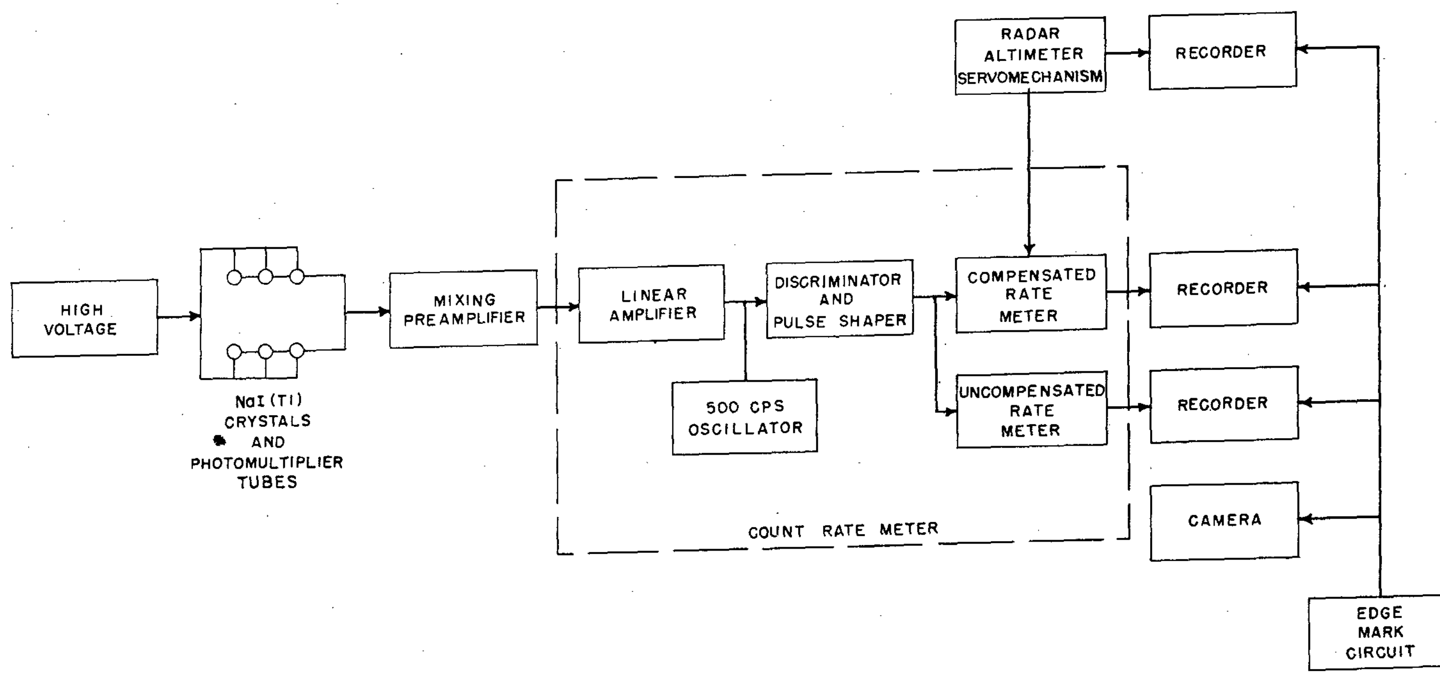


Fig. 2—Diagram of radioactivity survey equipment.

adequate in all areas but those having the most extreme topographic roughness. The limits of the compensator were exceeded in small areas of Green and Schoharie Counties, N. Y.

The gamma-ray flux at 2000 ft above the ground, which comes mainly from cosmic radiation and to a much lesser extent from radionuclides in the air, except after nuclear tests, is measured each day before surveying is started, and the assumed cosmic component is removed from the compensated circuit. A part of a regular flight line, called a test line, is flown at the beginning and end of each day's surveying. Through a comparison of these data, variations due to atmospheric and meteorological conditions and to equipment calibration may be obtained.

The effective area of response of the scintillation crystals at an altitude of 500 ft above the ground is a circle roughly 1000 ft in diameter, and the radioactivity recorded is an average of the radioactivity received within the area of response. Theoretical aspects of the area of response and other considerations are discussed by Sakakura[5], Gregory[6], and Moxham[7].

Several times each day the rate meter is calibrated with a resonant reed controlled oscillator, and the scintillation detection equipment is calibrated with a Cs^{137} source. A ground check of the crystals is made several times each week with a 10-microgram radium source.

The detection equipment is calibrated in counts per second (cps), which may be directly related to the average equivalent uranium content of the surface material. The sensitivity of the Geological Survey equipment has been expressed in many ways; Davis and Reinhardt (Ref. 3, p. 717) state "with a microgram of radium at one foot from the crystals, the counting rate is roughly 2,000 cps" and "when flying over a one gram radium source at 2,000 feet, an increase of 50 cps over background was noted". Davis and Reinhardt[8] also state "The count rates at 500 ft equivalent to a ground reading of 1 microroentgen/hour for Cs^{137} and Co^{60} plane sources are 25 and 18 cps respectively". Theoretical aspects of sensitivity are also discussed by Sakakura (Ref. 5).

1.5 Theoretical Considerations

The principal sources of the gamma-ray flux at 500 ft above the ground are cosmic radiation, radionuclides in the air (mostly radon daughter products), and radionuclides in the surface layer of the ground. It is difficult to accurately determine the contribution of each component at any particular time during the survey day; however certain assumptions on theory and calibration procedure permit reasonable estimates to be made.

The cosmic background is measured at 2000 ft above the ground twice each day and the assumed cosmic component at 500 ft above the ground is removed from the altitude-compensated circuit. Variations in this component during the survey day are difficult to separate from the other components, but they are believed insignificant in normal surveying.

Many variables, such as moisture content of the soil, temperature, barometric pressure, and wind velocity, affect the

concentration of radionuclides in the air. It is not uncommon in cases of temperature inversion to have a ten-fold increase in radon concentration. The gamma effect from radon concentration has not been fully evaluated, but it is believed to be insignificant in normal surveying.

The radioactivity of synthetic particles (fallout, cooling effluent gases, etc.) in the atmosphere may cause sharp or broad radioactivity anomalies, but these conditions were not encountered during the survey of this area.

The ground component of radioactivity measured at 500 ft above the ground comes mainly from the upper few inches of surface material and originates from natural radionuclides and radioactive fission products of fallout. Although an increase in measured radioactivity believed to be caused by fallout was noted during the survey of the southern part of the area in Oct. 1958 (Ref. 1), all of the area discussed in this report was flown in 1959 and 1960 and does not appear to be greatly affected by the fallout. This may be a result of the cessation of nuclear testing prior to September 1961 and the rapid decay of the short-lived fission products[9]. Gustafson, Marinelli, and Brar[10] concluded from a study of the radioactivity of soil at Lemont, Ill., that in the spring of 1957 the activity due to fallout was less than one-tenth of the total gamma activity of the soil. This conclusion is supported by the fact that less than 100 cps due to natural radioactivity and fallout was recorded over several large areas in the New England and New York portions of the project. Any fallout that may be present is assumed to be uniform over the area surveyed.

Of the naturally occurring radionuclides in the surface layer of the ground only members of the uranium and thorium decay series, and K^{40} are sufficiently abundant to affect the measured radioactivity. Trace amounts of these elements are found in all natural materials (Table 1). The concentration of these elements in the surficial material (glacial drift, soil, weathered rock, etc.) is determined by the original composition of the parent rock from which the surficial material was derived, and changes brought about by geologic and soil forming processes.

An important consideration in any study of the radioactivity of surficial material is whether the material is derived from the bedrock beneath it or whether it is derived from rock entirely different from that on which it is resting. The fact that the surficial material in the New York-New England area consists chiefly of unconsolidated glacial drift has an important bearing on the radioactivity of the area. It will be demonstrated later that the glacial material bears a close relationship to the underlying bedrock.

TABLE 1 - - APPROXIMATE AMOUNTS OF URANIUM, THORIUM, AND K^{40} IN COMMON ROCKS*

Common rocks	Uranium, ppm	Thorium, ppm	K^{40}, ppm
Ultramafic	0.001	0.004	0.005
Basaltic	1.0	4.0	0.99
Granodiorite	3.0	8.5	3.0
Granite	3.0	17.0	5.0
Syenite	3.0	13.0	5.7
Shale	3.7	12.0	3.2
Sandstone	0.45	1.7	1.3
Carbonate	2.2	1.7	0.32

* Adapted from Turekian and Wedepohl[11], assuming the isotopic abundance of K^{40} is 0.0119 percent of total potassium.

1.6 Compilation of Aeroradioactivity Data

Flight lines were plotted from the strip film onto base maps at a scale of 1 in. equals 1 mile (1:62,500). The altitude-compensated radioactivity profiles were compared with topographic maps of the same areas and all radioactivity lows attributable to lakes, ponds, rivers, or swamps were marked as such on the profiles (Fig. 3). This step was necessary because the glacial terrain is responsible for the numerous poorly drained areas in which lakes and swamp abound. These water bodies limit the source area by shielding the ground component, thus producing many lows on the radioactivity profiles. The amplitudes of the lows are proportional to the areal extent of the water within the area of response of the scintillation crystals. To reproduce all these lows on the aeroradioactivity map would greatly complicate it with numerous undesirable readings.

Adjacent aeroradioactivity profiles were then reexamined and significant changes or breaks in the level of radioactivity were correlated from line to line (Figs. 4a and 4b). The changes were plotted on overlays of the base maps and connected by solid or dashed lines depending on the degree of correlation. As would be expected

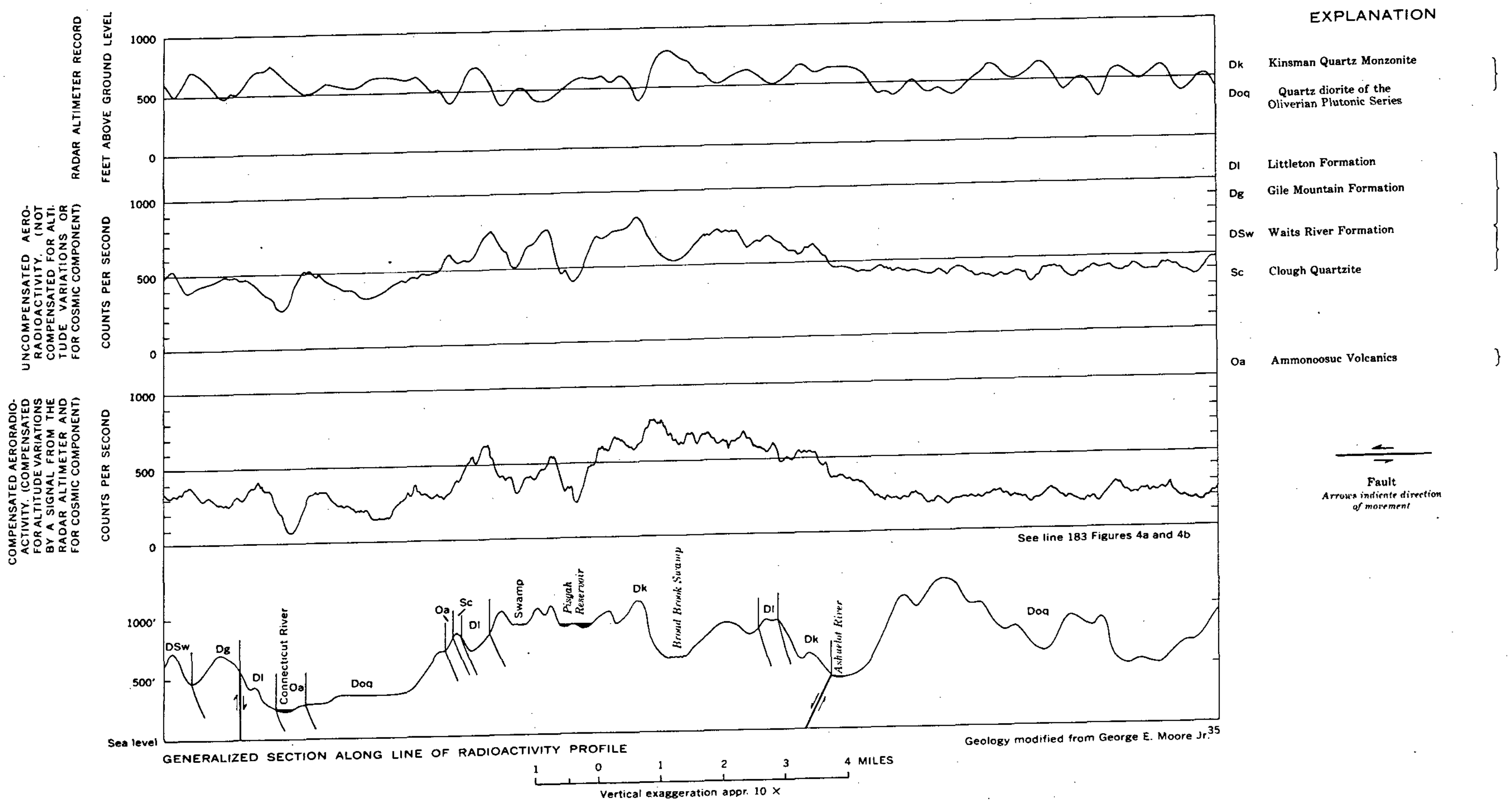


Fig. 3—Aeroradioactivity profile in the Keene and Brattleboro quadrangles, New Hampshire and Vermont, showing relation to bedrock geology and effects of topography, altitude, and water.

in a glaciated area many of the radioactivity boundaries are gradational, whereas others stand out quite sharply. The solid lines denote relatively distinct changes in radioactivity level, and the dashed lines denote relatively minor or subtle changes. After the records obtained over these specific areas had been scanned, the areas between the lines of change were assigned general ranges of radioactivity level.

The overlays were then photographically reduced and the data plotted on sheets of the Army Map Service, Corps of Engineers 1:250,000-scale, topographic map series. The final 1:250,000 map was thus derived (Pl. 1). This map is also published in the Geological Survey Geophysical Investigations Map Series[12].

2. GENERAL GEOLOGY

A detailed description of the geology is beyond the purpose and scope of this report, however, a general knowledge of the regional geology is necessary to better interpret the radioactivity pattern.

Parts of four physiographic provinces are included in the area (Fig. 5); the Appalachian Plateau province underlain by relatively flat lying Paleozoic shale, sandstone, limestone and dolomite; the Valley and Ridge province underlain by weakly folded Paleozoic shale, dolomite, limestone, and sandstone; and the New England and Adirondack provinces underlain chiefly by Precambrian and Paleozoic complexes of highly deformed schist, gneiss, and amphibolite of sedimentary and igneous origin.

Fig. 6 is a geologic sketch map compiled from published maps and descriptive literature. The geology of much of the area is currently being restudied and there is much unpublished or only informally published data that contradict existing maps. Only recently have geologists working in the region begun to have a good understanding of the complex metamorphic geology. The nature of many of the formations is poorly understood and discrepancies in origin, boundaries, names, and ages of many of the formations exist from state to state, or area to area. Some of the difficulty in bedrock mapping is caused by the mantle of glacial drift, but the major difficulties are the complex structure, high degree of metamorphism, deformation, igneous intrusion, and heterogenous lithology of the units. Many of the metasedimentary schists and gneisses have been intruded to such a degree that the rocks must be mapped as mixtures. In addition, reliable guide fossils on which age determinations may be based are very scarce in New England.

Most of the geologic data for Vermont are based on the new Centennial Geologic Map of Vermont by Doll, et. al. [13]. In New Hampshire the State Geological Map by Billings[14] is the major source of data. For Massachusetts detailed quadrangle maps were used where available, but most of the geology is based on the Preliminary Geologic Map by Emerson[15] published nearly a half century ago. For New York various data were used, primarily the Geologic Map of the Southern Taconics[16], geologic quadrangle maps, ground-water resources maps, and the 1901 Geologic Map of New York by Merrill[17].

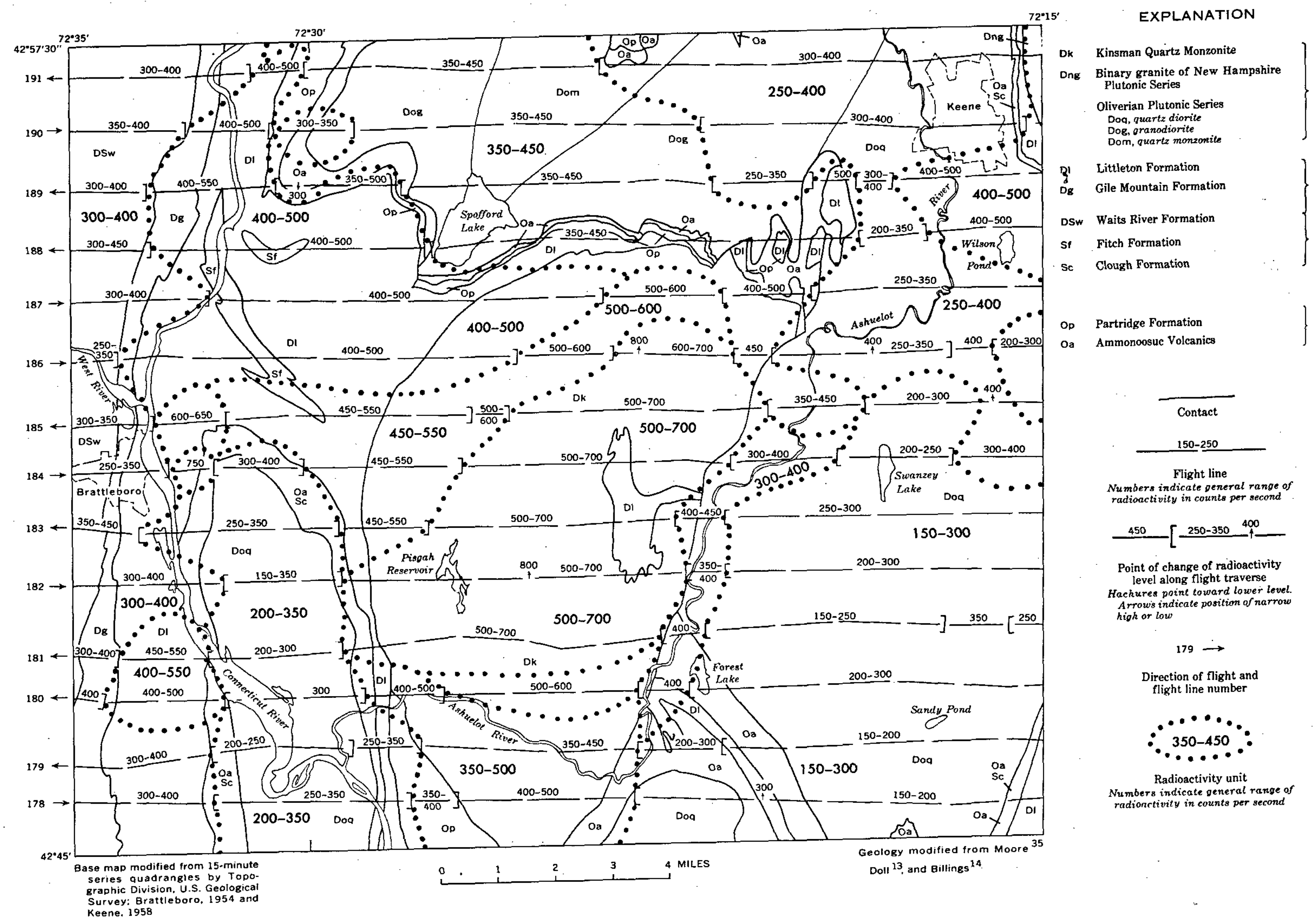


Fig. 4a—Detailed aeroradioactivity map of parts of the Keene and Brattleboro quadrangles, New Hampshire and Vermont, showing radioactivity units, geology, and flight lines.

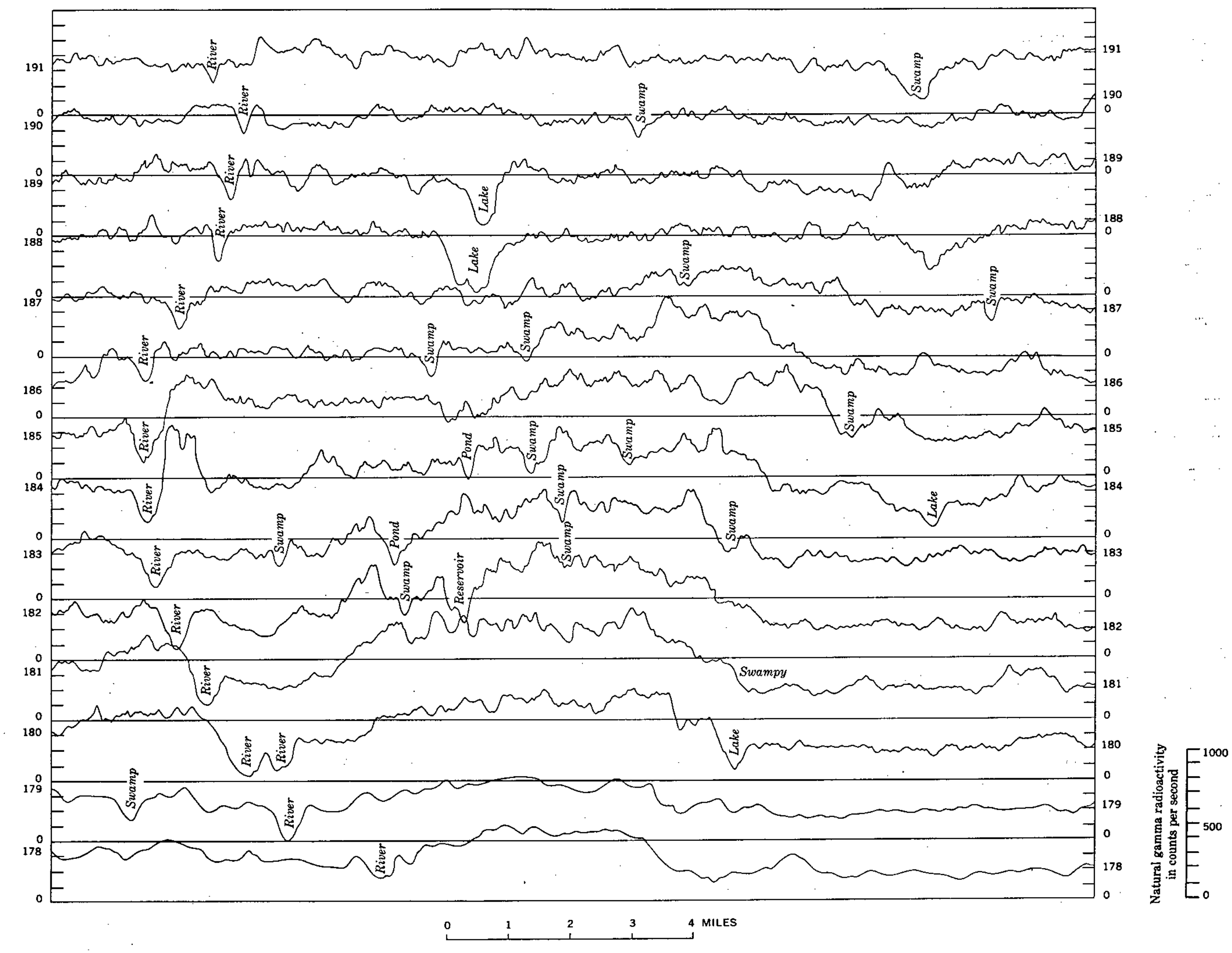


Fig. 4b—Aeroradioactivity profiles along flight lines 178 through 191 shown in Fig. 4a.

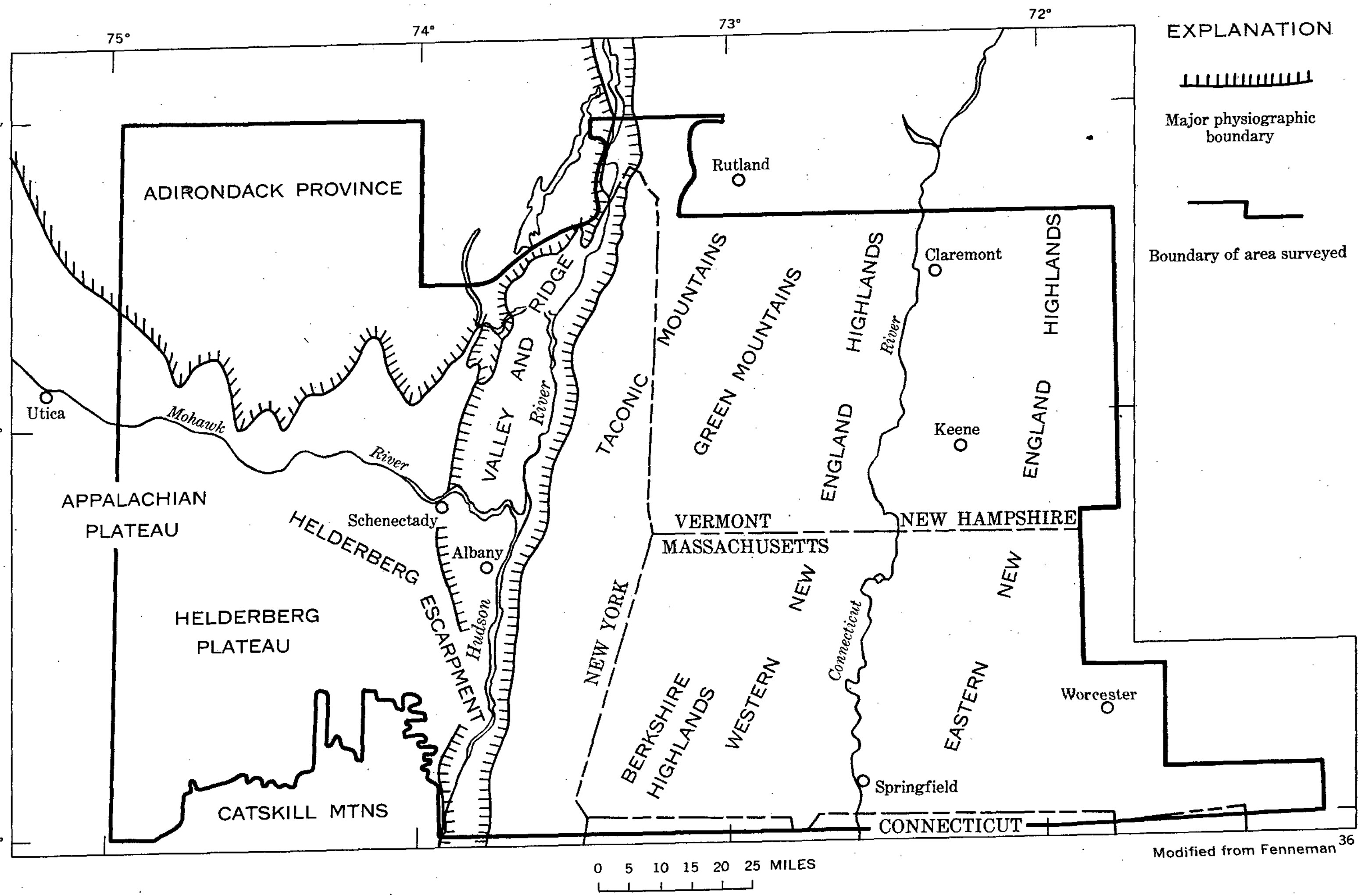
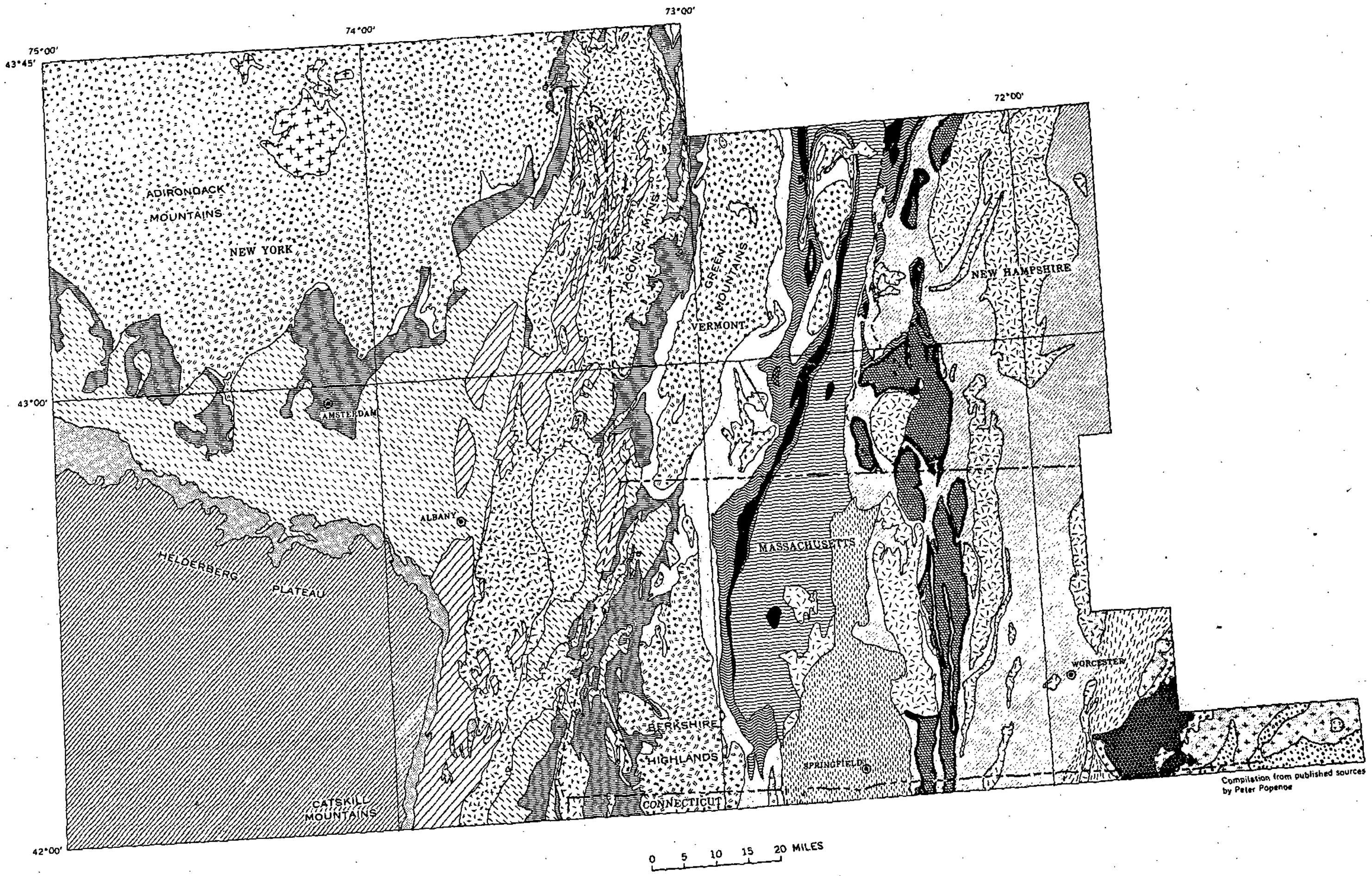


Fig. 5—Physiographic divisions of parts of east-central New York and west-central New England.



EXPLANATION

Upper Permian or Lower or Middle Triassic

TRIASSIC

Arkose, conglomerate, sandstone, and shale
Includes some basaltic rocks

PERMIAN OR TRIASSIC

Intrusive igneous stocks, chiefly syenite, gabbro, diorite, and granite
Chiefly White Mountain Plutonic-Volcanic Series

PENNSYLVANIAN

Conglomerate, arkose, sandstone, and shale

CARBONIFEROUS(?)

DEVONIAN(?)

Granodiorite, quartz diorite, quartz monzonite, and granite
Oliverian Plutonic Series

Granodiorite, granite, syenite
*Milford Granite, and rocks of the Dedham-Salem pluton**

DEVONIAN

Sandstone, shale, graywacke, and conglomerate

Phyllite, micaceous quartzite, interbedded volcanic rock, or higher grade metamorphic equivalents

ORDOVICIAN

Shale and sandstone

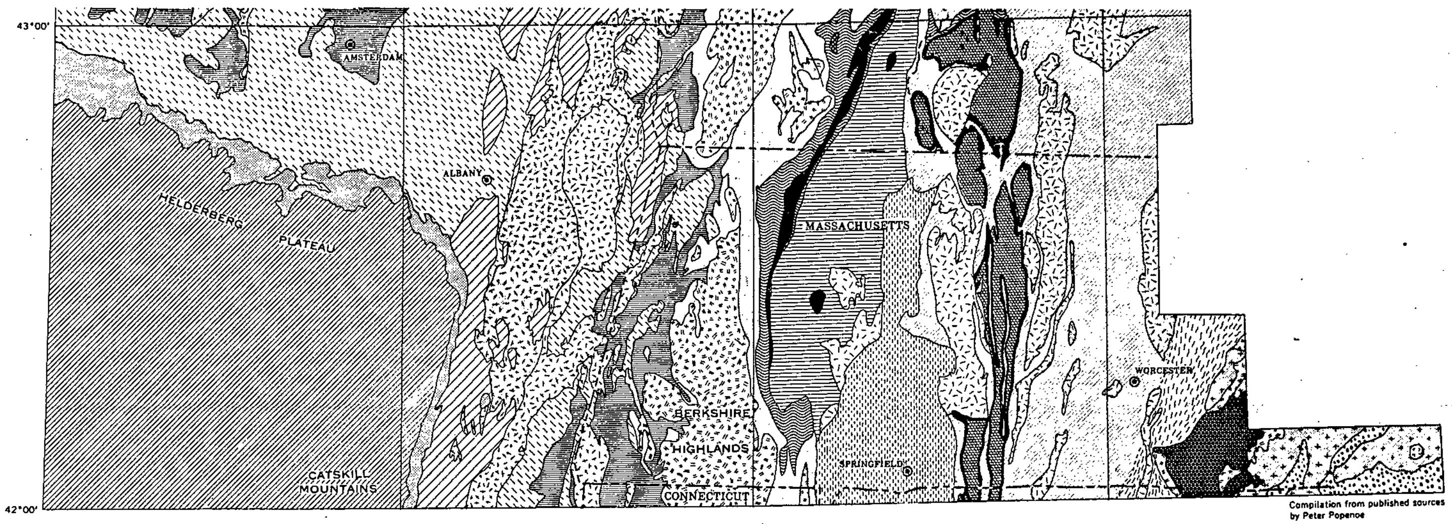
Shale, slate, and phyllite
Taconic sequence

CAMBRIAN AND OR ORDOVICIAN

Shale, phyllite, schist, graywacke
Taconic sequence

Limestone, dolomite, and marble

2



0 5 10 15 20 MILES

EXPLANATION

TRIASSIC

Arkose, conglomerate, sandstone, and shale
Includes some basaltic rocks

PERMIAN OR TRIASSIC (Upper Permian or Lower or Middle Triassic)

Intrusive igneous stocks, chiefly syenite, gabbro, diorite, and granite
Chiefly White Mountain Plutonic-Volcanic Series

PENNSYLVANIAN

Conglomerate, arkose, sandstone, and shale

CARBONIFEROUS(?)

Schist, phyllite, and quartzite

DEVONIAN(?)

Granite, quartz monzonite, quartz diorite, binary granite, granodiorite
New Hampshire Plutonic Series, and rocks not yet assigned to series but probably New Hampshire Plutonic Series

DEVONIAN(?)

Granodiorite, quartz diorite, quartz monzonite, and granite
Oliverian Plutonic Series

Granodiorite, granite, syenite
*Milford Granite, and rocks of the Dedham-Salem pluton**

DEVONIAN

Sandstone, shale, graywacke, and conglomerate

Phyllite, micaceous quartzite, interbedded volcanic rock, or higher grade metamorphic equivalents
Chiefly Littleton Formation, but includes other Paleozoic rocks

SILURIAN AND DEVONIAN

Quartzose and micaceous crystalline limestone, quartz-muscovite-phyllite or schist, micaceous quartzite, calcareous mica schist
Chiefly Waits River (Silurian and Devonian) and Gile Mountain (Devonian) Formations

Limestone, and interbedded shale

Middle or Upper Paleozoic

Dry Hill Granite Gneiss, Williamsburg Granodiorite, Dana Diorite, Belchertown Tonalite
Not yet assigned to a plutonic series

ORDOVICIAN

Ultramafic rocks
Dunite, peridotite, serpentinite, and talc-carbonate rocks

Quartzite, granulite, schist, and phyllite

Biotite gneiss, hornblende gneiss, and amphibolite
Chiefly metamorphosed volcanic rocks

ORDOVICIAN

Shale and sandstone

Shale, slate, and phyllite
Taconic sequence

CAMBRIAN AND ORDOVICIAN

Shale, phyllite, schist, graywacke
Taconic sequence

CAMBRIAN OR ORDOVICIAN

Limestone, dolomite, and marble

CAMBRIAN

Carbonaceous and noncarbonaceous schist, phyllite, quartzite, amphibolite, and gneiss

Shale, slate, phyllite, and graywacke, with minor amounts of sandstone and limestone
Taconic sequence

Sandstone and conglomerate

PRECAMBRIAN

Basement complex of highly metamorphosed rocks of sedimentary and igneous origin

Northbridge Granite Gneiss

Anorthosite

*Dating by total lead ratio in zircon indicates that rocks mapped as Dedham granodiorite have two ages, 260 MY and 350 MY 38.

Unconsolidated glacial drift covers perhaps 98 percent of the surface of the New York-New England area (Fig. 7) and outcrops exist only where bedrock projects through the glacial cover. Till, or boulder clay, an unsorted deposit, blankets most of the area. Several large lacustrine deposits of sorted silt, clay, and sand are present in the Hudson and Connecticut River valleys. Goldthwait[18] estimates the average thickness of the glacial deposits in New Hampshire to be 37 ft. Although accurate information as to depths of glacial material is lacking for much of the area, generally the most extensive deposits are located in the valleys, and the deposits are thin over the upland areas or steep slopes. Composition of the deposits is extremely variable but is generally relatable to the nearby bedrock which usually supplied the dominant material in the deposit. Thus deposits over shale are generally argillaceous, while those over areas of crystalline rock are general arenaceous.

3. GENERAL DISTRIBUTION OF RADIOACTIVITY

A summary of the radioactivity measured in the survey is shown in Fig. 8. Radioactivity levels ranged from less than 100 cps (counts per second) to 1150 cps, the average being about 500 cps.

The radioactivity map (Pl. 1) of the area demonstrates that the great majority of the glacial drift mantling the bedrock bears a close relationship to the underlying bedrock, except where its depth is too great, as in areas of lacustrine deposits, or along the contacts between formations where material from one formation is intermingling with that of another. Radioactivity boundaries are in most cases gradational owing to this intermingling of materials. It is surprising that bedrock radioactivity boundaries can be seen at all, but Nelson and Narten[19] found in a radioactivity study of Maine that "the radioactivity of the glacial materials is about the same magnitude as that of the rocks in the areas where they are found. It would thus seem that glacial debris from the eroded rocks of Maine has not been transported great distances". On the aeroradioactivity map many of the bedrock units may be traced for miles by their characteristic level regardless of the glacial cover.

Both sedimentary and igneous rocks show relatively high and low radioactivity levels. In the Appalachian Plateau province the radioactivity of the carbonate rocks generally range from 300 to 500 cps whereas the shale and sandstone generally range from 350 to 700 cps. The shale, phyllite, graywacke and limestone underlying the foothills of the Taconic Mountains generally range from 300 to 750 cps, but levels as high as 1050 cps are associated with the shale and phyllite underlying the Taconic Mountains. The New England and Adirondack provinces contain sedimentary and igneous rocks of varied radioactivity ranging from less than 100 to 1150 cps. Exceptionally low radioactivity (100 to 400 cps) is associated with the schist and gneiss of the Green Mountains and eastern Vermont, the igneous rocks of the Oliverian Plutonic Series of New Hampshire and eastern Massachusetts, and a large massif of anorthosite and areas of complex rock in the Adirondack Mountains of New York. Moderate to high

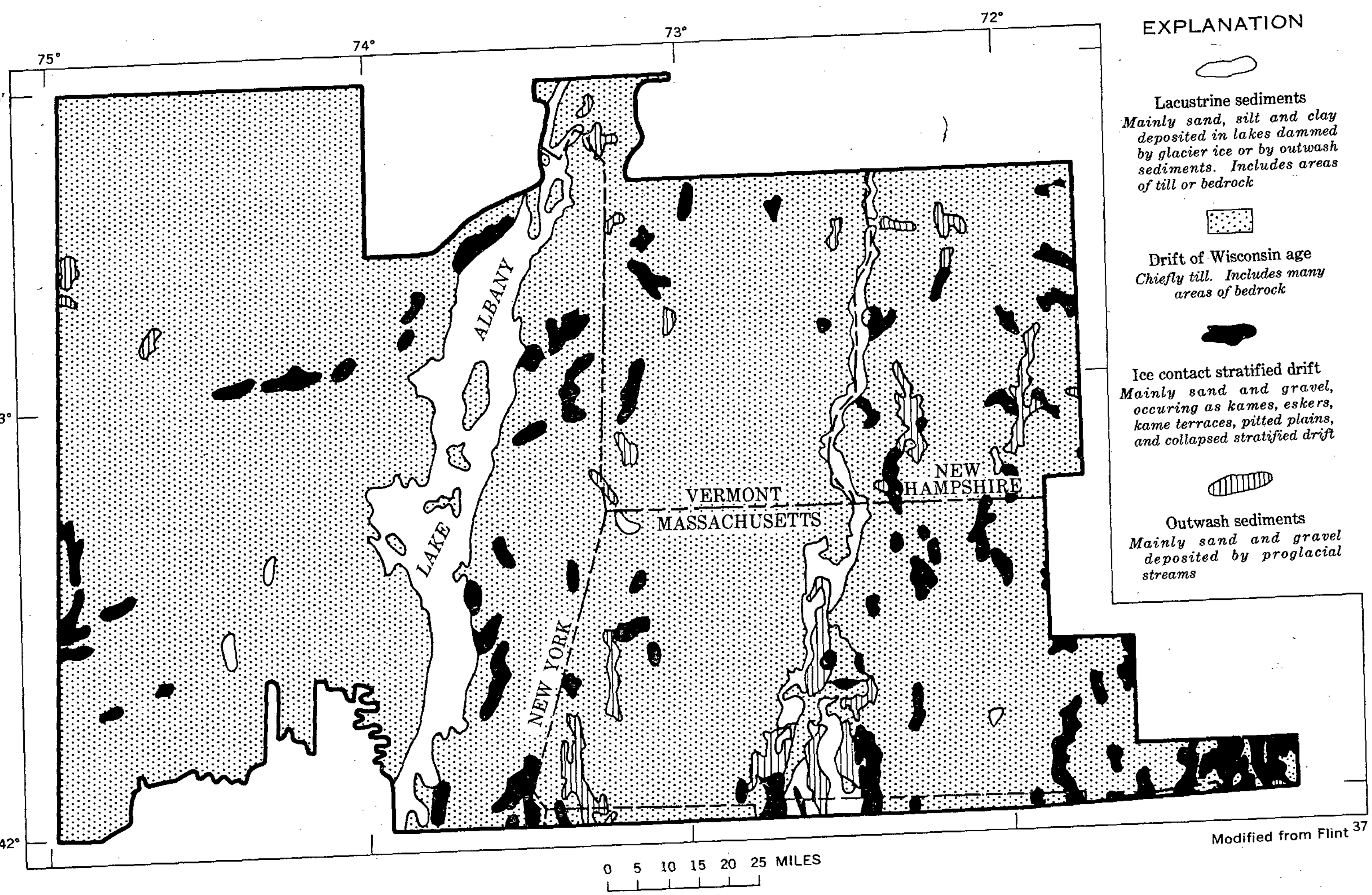


Fig. 7—Glacial map of parts of east-central New York and west-central New England.

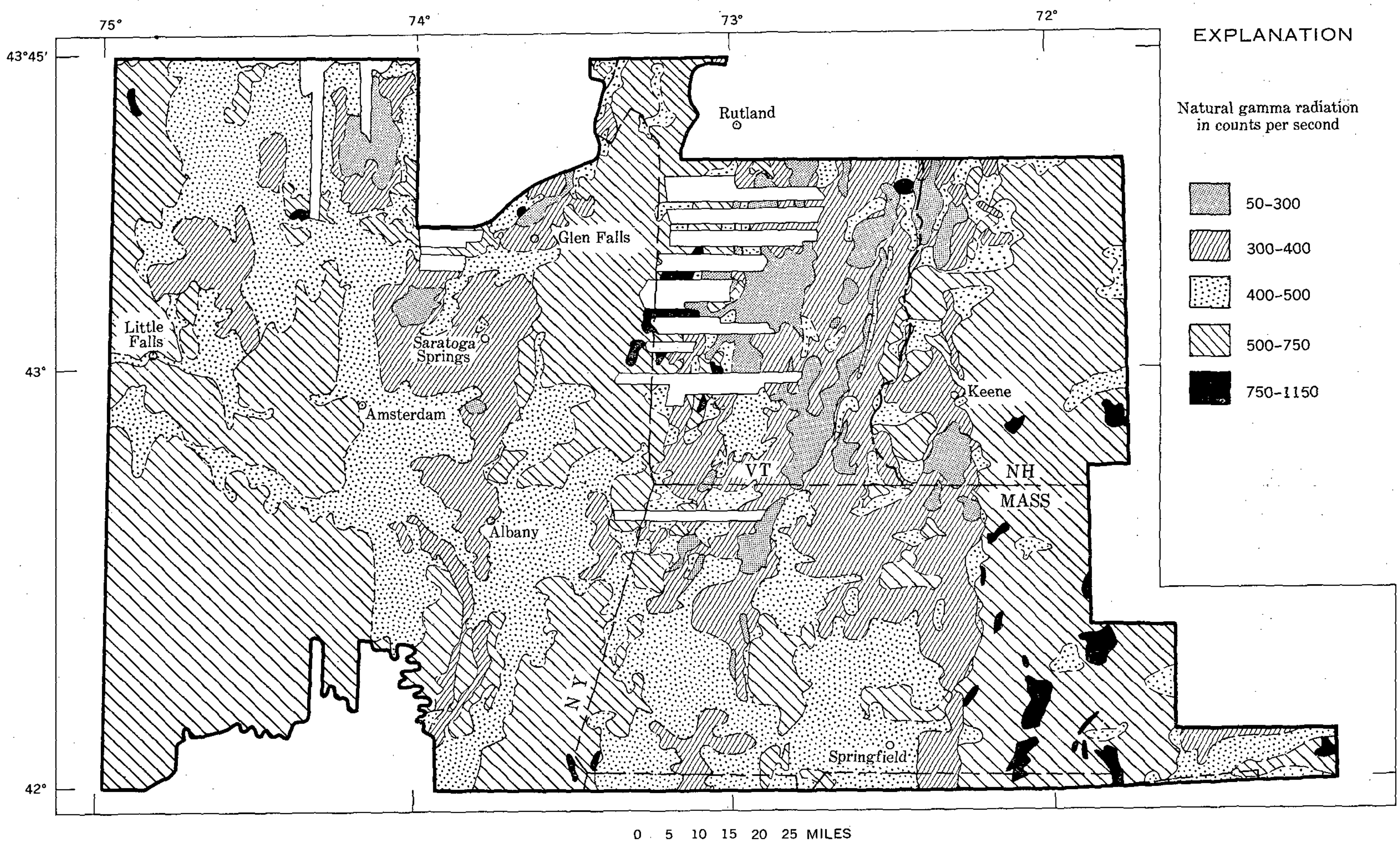


Fig. 8—Generalized aeroradioactivity parts of east-central New York and west-central New England.

radioactivity (400 to 1150 cps) is associated with a broad belt of igneous and metasedimentary rocks in New Hampshire and eastern Massachusetts, the Ascutney Mountain stock in Vermont, and locally in the Adirondack Mountains.

Glacial lacustrine deposits in the vicinity of Albany, N. Y., and scattered along the Connecticut River in Massachusetts generally have low associated radioactivity (200 to 400 cps). In many areas recent river or stream alluvium differs in radioactivity from the bedrock.

Several radioactivity highs were measured at or near Springfield, Mass. (1050 cps) and Schenectady, N. Y. (900 and 1000 cps). These measurements (Pl. 1) have no obvious geologic explanation and are believed not due to natural effects.

4. GEOLOGY AND RELATED RADIOACTIVITY OF THE APPALACHIAN PLATEAU AND VALLEY AND RIDGE PROVINCES

The sedimentary rocks of the Appalachian Plateau and Valley and Ridge provinces within the survey area range in age from Late Cambrian to Late Devonian. The rocks are relatively flat lying in the Appalachian Plateau, and become weakly folded and metamorphosed in the Valley and Ridge province before they disappear under the rocks of the Taconic thrust sheets.

The Upper Cambrian section resting unconformably on Precambrian rocks and cropping out at the margins of the Adirondack Mountains, consists of sandstone and conglomerate overlain by several formations of dolomite. A great thickness of massive gray Ordovician limestone overlies the Cambrian section. The Mohawk River valley is underlain by Ordovician black bituminous shale and gray calcareous shale with interbedded sandstone and limestone. Resistant Silurian and Lower Devonian limestone with lesser amounts of sandstone and thin bedded shale uphold the Helderberg escarpment, a prominent topographic feature to the south of the Mohawk River valley. Middle Devonian rocks, which are exposed at the surface in the Helderberg Plateau, consist predominantly of black bituminous shale in the west, grading eastward to bluish-gray sandy shale.

The Upper Devonian section exposed in the Catskill Mountains and foothills, is characterized by arkosic sandstone, siltstone, graywacke, some conglomerate, and greenish to reddish clay. The Upper Devonian generally consists of marine shale near its base and grades upward to continental red beds.

Radioactivity levels range from 200 to 1050 cps. The level of the Cambrian and Lower Ordovician carbonate section generally ranges from 300 to 500 cps, but in many areas that section is not separable by radioactivity from the Ordovician shale sequence. The radioactivity of the Ordovician shale exposed along the Mohawk Valley ranges from 300 to 750 cps. Generally the shale is higher in radioactivity (500 to 650 cps) in the western part of the area, and lower (350 to 500 cps) west of Schenectady, N. Y., where the section contains abundant sandstone.

The resistant Silurian and Lower Devonian limestone sequence along the Helderberg escarpment forms what is perhaps the best

exposure of bedrock in the project area. The carbonate sequence is marked by a distinct radioactivity low (generally 300 to 500 cps).

Radioactivity of the Middle Devonian marine shale exposed on the Helderberg Plateau generally is from 400 to 600 cps in level, but several large areas in Schoharie and Otsego Counties, N.Y., average 500 to 700 cps. The Upper Devonian Catskill red beds generally range from 450 to 600 cps in level.

Locally, in Green and Schoharie Counties, radioactivity levels range from 700 to 1050 cps in steep-sided valleys. Comparison of the radioactivity profiles and altimeter records over these areas indicate that these anomalous values are due to overcompensation by the altitude-compensated circuit in the Geological Survey equipment, rather than to natural radioactivity.

Analyses of the Paleozoic rocks of the Hudson and Mohawk valleys by Narten and McKeown[20] indicate that "In the Paleozoic rocks the average radioactivity of the most strongly radioactive rocks is 0.003 percent equivalent uranium".

In the Hudson River valley low radioactivity levels averaging 250 to 400 cps are associated with lacustrine sand, gravel, and clay deposited in the glacial Lake Albany (Fig. 7). A significant radioactivity break occurs along a north-south line in the center of the lake deposits. It is interesting that northeast of Saratoga Springs, N. Y., where the change in level is particularly pronounced, the break occurs near the location of a fault mapped by Cushing and Ruedemann[21]. On the east side of the fault the Snake Hill Formation, a unit lithologically similar to the rocks of the Taconic sequence is present, and on the west side the Canajoharie Shale, a black shale, is present. The Snake Hill Formation is now thought to be a facies of the Canajoharie Shale. The fault shown by Cushing and Ruedemann corresponds closely to the place where the cleaved rocks merge into uncleaved rocks[22]. It seems that the change in level is not due to a difference in the bedrock, but may be due to a difference in source area for the lake sediments, those on the west derived from the Precambrian Adirondack region, and those on the east derived from the Taconic Mountains.

5. GEOLOGY AND RELATED RADIOACTIVITY OF THE NEW ENGLAND AND ADIRONDACK PROVINCES

5.1 Adirondack Province

The Adirondack Mountains of New York are underlain by a complex of Precambrian metasedimentary and meta-igneous rocks. The meta-sedimentary rocks, known as the Grenville Series, are dominantly marble, quartzite, amphibolite, and biotitic, garnetiferous, and sillimanitic gneiss. These rocks are moderately to highly deformed, and injected with anorthosite, gabbro, diorite, syenite, and a granitic complex, which have interacted with the metasediments to produce hybrid rocks and skarns. Paragneisses were injected lit-par-lit with magma and partially granitized by magmatic fluids which permeated the rocks. Some granites are not separable from granitized sediment or migmatite[23].

Radioactivity levels of the Precambrian rocks are generally below 500 cps, except near the western boundary of the project where they are slightly higher (up to 700 cps). A large massif of anorthosite exposed mainly in the Thirteenth Lake quadrangle[24] in northwestern Warren County, N. Y., is exceptionally low in level (150 to 350 cps). Large areas of rocks of anomalously low radioactivity are also found at the intersection of Herkimer, Fulton, and Hamilton Counties, N. Y., where quartz-feldspar-garnet gneiss and mixed granite, syenite, and Grenville rocks are 200 to 400 cps in level; and at the southeastern extension of the Adirondack Precambrian complex in Saratoga County, N. Y., where Grenville rocks and syenite are 100 to 400 cps in level. High levels are scattered throughout the area, the highest just west of the anorthosite massif (1150 cps), and another sharp high of 1050 associated with a known uranium-rich pegmatite located just north of the Sacandaga Reservoir in Fulton County, N. Y. Investigations by Narten and McKeown (Ref. 20, p. 23) in the Adirondack Mountains indicate that "although there are many abnormally radioactive rocks and glacial materials, particularly near the contacts of igneous and metamorphic rocks, pegmatites are the only known sources of concentrations of radioactive elements".

5.2 Western New England Highlands

5.2.1 Taconic Mountains

Underlying the Taconic Mountains and the foothills to the west is a sucession of Cambrian and Ordovician clastic rocks, primarily micaceous and quartz-silt shale, purple and green shale and slate, red slate, quartzite, graywacke, and interbedded black shale and limestone. Dikes of diabase, albite basalt, and tuffs are present in the Taconic clastics indicating eugeosynclinal deposition. These clastics have relatively great north-south extent, relatively small east-west extent, and are surrounded by and rest discordantly on contemporaneous miogeosynclinal carbonates and orthoquartzites[25]. The Taconic rocks are bounded on the west by a fault, or zone of faults known as "Logan's Line", but the nature of the eastern boundary is in doubt, for the Taconic rocks rest against and are metamorphosed with similar Ordovician argillaceous rocks that obscure the character of the contact.

Many hypotheses have been proposed to explain the apparent anomalous position of the Taconic rocks. Those of the north are thought to be a number of klippen, which have been thrust into their present position from a source area to the east (Ref. 25, p. 326). The emplacement of the rocks of the southern Taconics is controversial in nature with several hypotheses proposed to explain their structure and lithology (Ref. 16).

The miogeosynclinal rocks bounding the eastern edge of the Taconic sequence are equivalent with and lithologically similar to the Cambrian and Ordovician sequence of the Hudson and Champlain Valleys. Resting on the Precambrian rocks of the Green Mountains and Berkshire Highlands are Lower Cambrian quartzites and conglomerates. Cambrian and Ordovician carbonate rocks that overlie

the clastic sequence are described as gray, pinkish, and brown dolomite, white to gray marble, and calcareous sandstone and quartzite (Ref. 13). At the top of the section are black carbonaceous and pyritic slate and phyllite which correspond to the Snake Hill Formation of the Champlain Valley (Ref. 22).

Radioactivity levels over the rocks of the Taconic sequence range from 300 to 1050 cps. The highest levels of radioactivity, averaging 500 to 800 cps, are associated with the variegated slate and phyllite underlying the Taconic Mountains along the New York-Vermont state line. Medium high levels of 450 to 700 cps are also associated with the shale and slate in the foothills of the Taconic Mountains in Washington County, N. Y. In Rensselaer and Columbia Counties, N. Y., medium low levels of 300 to 500 cps are associated with the Rensselaer Graywacke and the Cambrian clastic rocks of the Taconic sequence.

Radioactivity levels of the quartzite-carbonate sequence range from 100 to 950 cps, but generally are below 600 cps. In Vermont a large area of the sequence is exceptionally low (100 to 300 cps) in level. The level increases in Massachusetts to an average of 300 to 500 cps. In many localities the bedrock in the valleys is mantled with a thick blanket of talus, glacial drift, and alluvium, which is the source of the gamma radiation.

5.2.2 Green Mountains

The Green Mountains of Vermont within the surveyed area are underlain by a complex of Precambrian metasedimentary and meta-igneous rocks similar to those of the Adirondack Mountains. The metasedimentary rocks, known as the Mount Holly Complex, consist dominantly of biotitic, muscovitic, and chloritic gneiss, hornblende gneiss, quartz mica schist, calcite and dolomite marble, micaceous quartzite, and amphibolite.

The metasedimentary rocks are intruded by both mafic and felsic igneous rock. At the southern tip of the Green Mountains the Mount Holly Complex is intruded by the Stamford Granite Gneiss, a gray coarse-grained, porphyritic granite gneiss with megacrysts of perthitic microcline. Elsewhere intrusions of gneissic biotite granite, quartz monzonite, granodiorite, and "white gneiss" with quartz, microcline, albite, and biotite are present. A small stock, mainly nepheline syenite and pulaskite, intrudes the complex near Cuttingsville, Vt.[13,26,27].

East of the Green Mountains several large areas of Precambrian rocks crop out in the cores of dome and nappe structures. These rocks are largely banded gneisses of granodioritic or quartz dioritic composition with minor amounts of biotite amphibolite and a few lenses of schist and quartzite[28].

Radioactivity levels associated with the rocks of the Green Mountains are generally low. That of a large central area of the Mount Holly Complex is exceptionally low (100 to 300 cps) and most of the complex is generally below 500 cps. Locally, the Mount Holly Complex has zones of rock displaying higher radioactivity. Northeast of Bennington, Vt., several zones strike north-south, and have associated radioactivity varying from 100 to 1000 cps. The

Cuttingsville, Vt., stock has a small "high" of 700 cps associated with it. A large portion of the Green Mountains could not be flown because of the rugged topography, and it is possible that some of the radioactivity values recorded over the complex are incorrect because of the limitations of the altitude-compensated circuit of the scintillation equipment.

The Precambrian rocks exposed in the dome and nappe structures to the east of the Green Mountains are uniformly low in radioactivity (generally 150 to 400 cps and rarely more than 500 cps).

5.2.3 Berkshire Highlands

South of the Green Mountains a complex of Precambrian age gneiss and schist of sedimentary and igneous origin forms the core of the Berkshire Highlands. The metasedimentary sequence includes quartzite gneiss, actinolite-epidote gneiss, muscovite-biotite-epidote schist, biotite amphibolite, garnetiferous gneiss, quartzite, and marble. As in the Green Mountains to the north, the closely folded sedimentary rocks have been invaded and altered by mafic and felsic igneous magma, locally with considerable absorption of material. The common orthogneiss is a medium-to fine-grained, light-colored biotite-(or biotite-muscovite) microcline-oligoclase gneiss. Locally there are small areas of light-colored porphyritic granite[15,29,30].

Radioactivity levels over the Berkshire Highlands generally range from 300 to 500 cps. Higher levels are found locally but none of these exceed 800 cps.

5.2.4 Eastern Vermont and West-central Massachusetts

The remainder of the western New England Highlands is underlain chiefly by a broad belt of mica schist and quartzite, interstratified with green schist, amphibolite, and gneiss, all of Paleozoic age. The mica schist and quartzite are metamorphosed shale and sandstone and the green schist, amplibolite and gneiss are largely metamorphosed volcanic rock. Igneous rocks ranging in composition from serpentinized dunite to granite are intrusive into the metasedimentary and metavolcanic rocks. Several large granodiorite and quartz diorite intrusions are present in Massachusetts, and these are similar to the intrusive rocks of the Eastern Highlands.

On the geologic sketch map (Fig. 6), the Western Highlands has been divided into three metasedimentary units, based primarily on age; the Cambrian, the Ordovician (separated into two units, one chiefly of sedimentary origin and the other chiefly volcanic origin) and the Devonian. The Silurian section, which is of small areal extent, is included with the Devonian section.

The Cambrian section is characterized by schist, phyllite, and gneiss, with interbedded amphibolite, greenstone, quartzite and dolomite (Ref. 13). The radioactivity over the sequence generally ranges from 200 to 500 cps. Locally, particularly over Lower Cambrian schists, the level reaches 600 cps. Radioactivity of most of the Cambrian formations of Massachusetts is 300 to 500 cps in level.

The Ordovician rocks, particularly the volcanic rocks, are among the best defined by radioactivity lows on the map. The Barnard Volcanic Member of the Missisquoi Formation, mainly biotite gneiss, hornblende gneiss, and amphibolite (Ref. 13) shows a low of 100 to 300 cps that can be traced across Vermont to the vicinity of West Cummington, Mass. Similarly, a low occurs east of Ascutney Mountain, over volcanic members of the Partridge Formation, and around the margins of the Oliverian Plutonic Series of New Hampshire (Ammonoosuc Volcanics). Most metasedimentary rocks in the Ordovician section, consisting of quartzite, granulite, schist, and phyllite, are below 400 cps in radioactivity in Vermont and northern Massachusetts and below 500 cps in southern Massachusetts. Several ultramafic bodies intrude the Ordovician rocks. The largest ultramafic intrusion near East Dover, Vt., is represented by a low of 150 to 250 cps.

The Devonian metasedimentary formations of the Western Highlands have been grouped into two units on Fig. 6; the Littleton Formation, discussed later under the Eastern Highlands section, and the Gile Mountain and Waits River Formations. The Waits River Formation (which is Silurian and Devonian in age) is chiefly gray quartzose and micaceous marble interbedded with gray quartz-muscovite phyllite or schist. The Gile Mountain Formation is chiefly gray quartz-muscovite phyllite or schist interbedded and intergradational with gray micaceous quartzite, calcareous mica schist, and locally quartzose and micaceous marble (Ref. 13). Both formations have volcanic members. Radioactivity of the two formations is generally below 450 cps in level in Vermont and increases in level toward the southern part of the belt in Massachusetts, where it attains a level of 450 to 650 cps near Huntington, Mass. Several large igneous bodies occur within the Devonian belt, but these generally are not discernible by radioactivity measurements.

A consistent change in radioactivity level occurs between the Devonian rocks of the Western Highlands (Waits River, Gile Mountain Formations) and those of the Eastern Highlands (Littleton Formation, etc.). The break occurs just west of the Connecticut River and can be traced to where the formational boundaries disappear beneath the Triassic rocks of Massachusetts. The rocks of the Western Highlands area are generally low whereas those of the Eastern Highlands are noticeably higher in level.

The most highly radioactive rocks in the area occur at Ascutney Mountain in the northeastern part of the belt. Here a large stock containing comagmatic intrusions of gabbro, diorite, syenite, and granite has invaded the schist and gneiss[31]. The rocks are similar to, and classed with, the White Mountain Plutonic-Volcanic Series of New Hampshire. The granite at Ascutney Mountain has a radioactivity level of 1100 cps, the gabbro diorite has a low level of 200 to 300 cps.

5.3 Triassic Rocks of Central Massachusetts

In central Massachusetts continental clastic rocks of Triassic age consisting chiefly of unmetamorphosed arkose, sandstone, conglomerate and shale underlie the Connecticut River Valley and extend southward into Connecticut. Basaltic lava flows are inter-

bedded with the clastic rocks and crop out in a narrow belt in the west-central part of the area. The coarser clastics were deposited as alluvial fans by streams which dumped their load of gravelly wash into a structural trough; the finer clastics are largely lacustrine or palustrine deposits[32]. The beds strike north and dip toward the east.

The radioactivity level of the Triassic rocks is a fairly uniform 300 to 500 cps. Locally the radioactivity level reaches 600 cps, possibly owing to a different source area for the sedimentary or glacial material. The basaltic lava flows generally have a slightly lower level (250 to 400 cps), but in most areas they do not have sufficient areal extent for their effect to be noticeable. Glacial lacustrine deposits with low radioactivity (200 to 400 cps) are present along the Connecticut River (Fig. 7). The contact of the Triassic rocks with the surrounding Paleozoic rocks is not discernible by radioactivity except in the southwest corner of the area where the Paleozoic rocks are slightly higher in level.

5.4 Eastern New England Highlands

East of the Connecticut River the bedrock of the New England Highlands is extremely complex. These rocks generally consist of phyllite, micaceous quartzite, and interstratified volcanic rocks, or their higher-grade metamorphic equivalents, which have been intruded by numerous types of igneous rocks (chiefly granite, quartz monzonite, quartz diorite, and granodiorite). The meta-sedimentary rocks are mainly of marine origin, originally arenaceous shales and argillaceous sands, mostly of Paleozoic age. At many places the sedimentary rocks are intricately intruded, both lit-par-lit and by granitization. All of the rocks have been regionally metamorphosed, chiefly to the sillimanite grade, and deformed (Ref. 14, p. 28).

On the basis of radioactivity the eastern New England Highlands within the project boundaries can be roughly divided into zones from west to east: a western zone of medium radioactivity, a zone of low radioactivity associated with the Oliverian Plutonic Series, a central zone of relatively high radioactivity, and an eastern zone of low to medium radioactivity.

The western zone of medium radioactivity is present mainly in Massachusetts and contains Devonian and older sedimentary rocks, and Paleozoic igneous rocks. On the geologic sketch map (Fig. 6), it includes the unit marked as Dry Hill Granite Gneiss, Williamsburg Granodiorite, Dana Diorite, and Belchertown Tonalite, and the surrounding metasedimentary rocks. The zone generally ranges from 300 to 600 cps. There is no difference in the radioactivity of the igneous or sedimentary rocks, and the belt is not distinguishable by radioactivity from the Triassic rocks to the west.

The second zone, of low radioactivity, is comprised of a discontinuous series of domes, collectively called the Bronson Hill anticline. These domes have cores of igneous intrusive rocks and are surrounded by metamorphosed Ordovician volcanic rocks. In New Hampshire, where the domes are extensively developed, the granite, quartz monzonite, and granodiorite that make up the domes have

collectively been assigned to the Oliverian Plutonic Series because of their lithologic similarity and structural position. The boundaries of the various rock types within the domes cannot be precisely located because they are transitional into one another. The rocks of the series are generally pink, medium- to coarse-grained, characteristically foliated, and commonly found near the top of the Ammonoosuc Formation, a series of Ordovician metavolcanic rocks. Most of the rocks of the series are older than or contemporaneous with deformation (Ref. 14, p. 52).

The volcanic rocks surrounding the domes are of two principal kinds: dark-green chlorite and chlorite epidote schist, and buff to white soda rhyolite that is massive to schistose. Some dark slate and impure gray quartzite are mixed with the volcanic rocks. The bedding, as well as the fragmental texture, indicates that most of the metavolcanic rocks are of phyroclastic rather than flow origin. These volcanic rocks are similar to, and have been correlated with the Ordovician volcanic rocks of the Western Highlands, which include the Barnard Member of the Missisquoi Formation, and volcanic members of the Partridge Formation (Ref. 13).

The granite, quartz monzonite, granodiorite, and the volcanic rock surrounding the domes have strikingly low radioactivity. Most of the Oliverian plutonic rocks are characteristically low in radioactivity (generally 150 to 400 cps) and can easily be traced across the project area by this associated low radioactivity. The exception is at one locality in the Sunapee quadrangle, near the north edge of the area, where the quartz diorite and quartz monzonite in the Croydon dome ranges from 500 to 700 cps with a small high of 900 cps. Where the individual rock types are mapped separately on geologic quadrangle maps, there appears to be a slight difference in the associated radioactivity. The quartz diorite, where mapped separately, generally ranges from 150 to 350 cps, and the quartz monzonite, granodiorite, and surrounding volcanic rocks generally range from 300 to 400 cps (Fig. 4a).

The central area of the Eastern Highlands contains as a whole the highest levels of radioactivity in the northern New England project area. The bedrock is generally metamorphosed shale and sandstone of Devonian age (mainly Littleton Formation), into which have been intruded many igneous bodies. Some gneiss, schist, quartzite, and igneous rocks of Carboniferous and Precambrian age are present in the eastern part of the zone. Most of the central area is metamorphosed to andalusite or sillimanite grade. Many of the metasedimentary rocks are highly migmatized and metasomatized, and some of the igneous rocks contain inclusions of metasedimentary rock.

Billings[14] has classed the Devonian(?) igneous rocks that intrude the central zone in New Hampshire into the New Hampshire Plutonic Series, and rocks unassigned to series, but probably New Hampshire Plutonic Series. The dominant rock types are quartz monzonite, granodiorite, granite, biotite gneiss, and quartz diorite.

The average radioactivity of the central belt of rocks in New Hampshire is 400 to 700 cps. A large intrusion of quartz monzonite in the southwestern part of the state (500 to 700 cps) stands out in sharp contrast to the surrounding rocks of lower radioactivity (Fig. 4). Elsewhere there appears to be little difference in radio-

activity between the igneous and sedimentary rocks. Local high readings are found throughout the state over both igneous and sedimentary rocks. Several of the highest readings (up to 950 cps) occurred over Mount Monadnock, N. H., which is underlain by sedimentary rocks, and over and around a body of quartz diorite near Lyndeboro, N. H.

To the south in Massachusetts the average radioactivity of the central zone increases to 550 to 750 cps. The Paxton Quartz Schist of Massachusetts is slightly lower with an average level of 400 to 600 cps. Levels of 900 cps are present over rocks of both igneous and sedimentary origin. In the southeastern corner of the zone the Northbridge Granite Gneiss, a gneissoid porphyritic microcline-biotite granite of Precambrian age, ranges in radioactivity from 400 to 1000 cps. This rock is generally higher near its western margin and lower along its eastern margin. The radioactive zoning may be due to magmatic segregation, but it is possible that detailed geologic mapping will show several distinct rock types within the unit.

Johnson[33] and McKeown[34] have studied the central zone of high radioactivity in Massachusetts and New Hampshire and have concluded that "The radioactivity of the rocks of the central New England province is considered to be due mainly to thorium, as uranium analyses to date have not shown more than 0.001 percent uranium" (Ref. 34, p. 24).

Although the southeastern extension of the project just touches a zone of low to medium radioactivity, the rock types present are characteristic of a broad area in eastern Massachusetts and in Rhode Island. Two major bodies of igneous rock are present in the survey area; the Dedham Granodiorite, and the Milford Granite. The Dedham Granodiorite is typically a pale pink, coarse-grained biotitic granodiorite composed essentially of microcline, plagioclase, quartz, and biotite altered to chlorite. The Milford Granite is typically coarse-grained, alkalic pink granite containing biotite as its dark constituent and rounded blue quartz[15].

Radioactivity levels over these plutonic rocks are generally low. Over the greater portion of the Milford Granite the level is a uniform 300 to 400 cps. The southern end of the Milford Granite and the greater portion of the Dedham Granodiorite range from 350 to 600 cps. A stock of porphyritic riebeckite granite which has relatively high radioactivity (850 to 950 cps) intrudes the Dedham Granodiorite at the tip of the southeastern project extension.

Clastic rocks of Pennsylvanian age are exposed in the extreme southeastern corner of the project area. These rocks consist of slightly metamorphosed conglomerate, arkose, sandstone, and shale of nonmarine origin. Radioactivity levels range from 350 to 500 cps.

6. SUMMARY

The natural gamma radioactivity in the project area ranges from less than 100 cps to 1150 cps, averaging about 500 cps. Comparison with geologic maps indicates that the level of radioactivity is closely related to the type of bedrock underlying soil or glacial

deposits and subordinately related to the glacial deposits. The association of radioactivity level with bedrock type is locally so good that some geologic units may be traced for miles by their characteristic level.

Rocks of both sedimentary and igneous origin produced high and low levels of radioactivity. Three large areas containing rocks of moderate to high radioactivity are present: one associated with clastic rocks of Devonian age in the Helderberg Plateau and foothills of the Catskill Mountains; another associated with phyllite and slate of Cambrian and Ordovician age in the Taconic Mountains and foothills; and the third associated with a broad belt of phyllite, micaceous quartzite, volcanic material and intrusive igneous rock, chiefly of Devonian age, in New Hampshire and east-central Massachusetts. Low radioactivity is associated with a massif of anorthosite in the Adirondack Mountains, a large part of the Precambrian complex of the Green and Adirondack Mountains, the Cambrian, Ordovician, and Devonian sedimentary sequence of eastern Vermont, the igneous rocks of the Oliverian Plutonic Series and surrounding volcanic rocks, and glacial lacustrine deposits along the Hudson and Connecticut Rivers.

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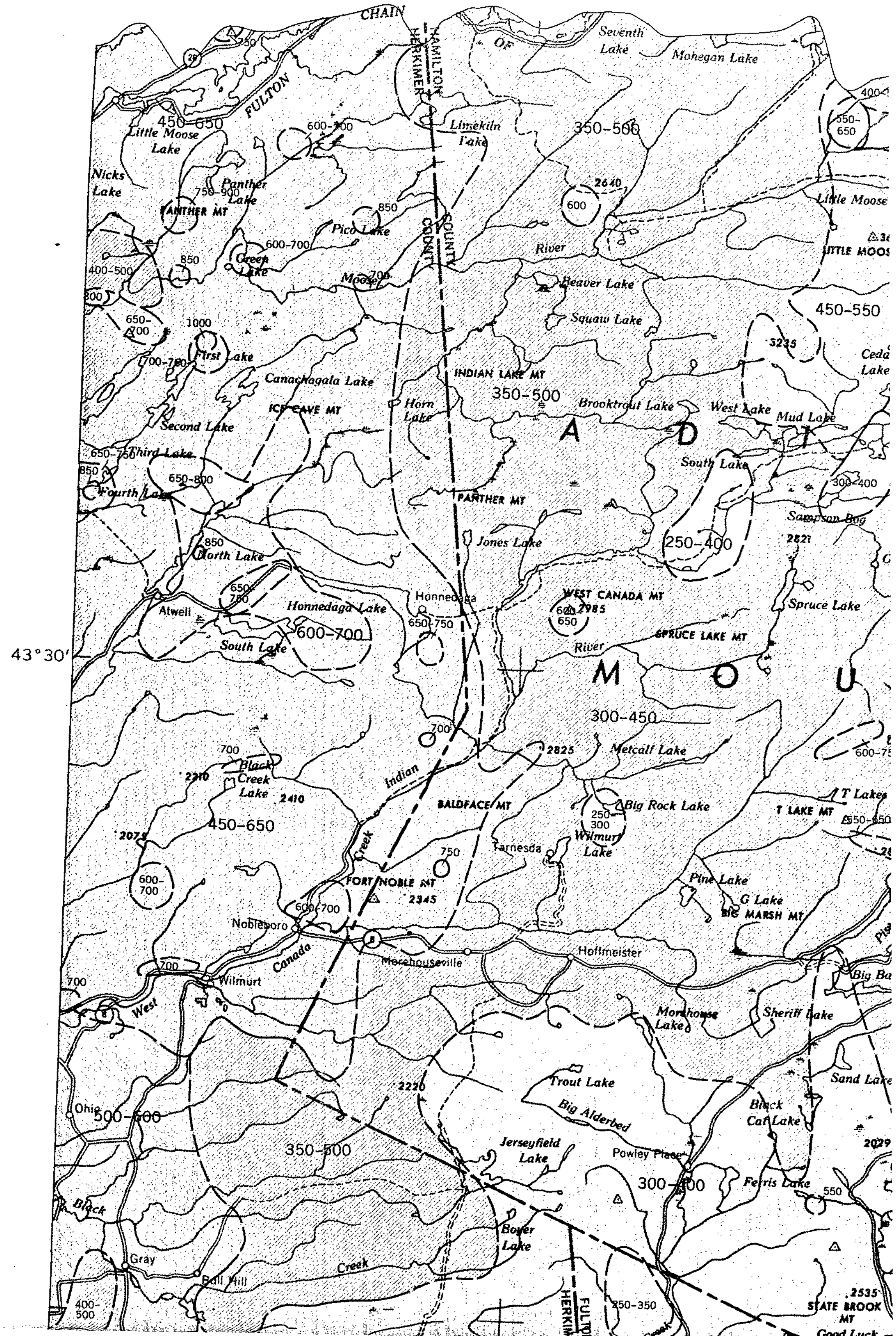
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

1



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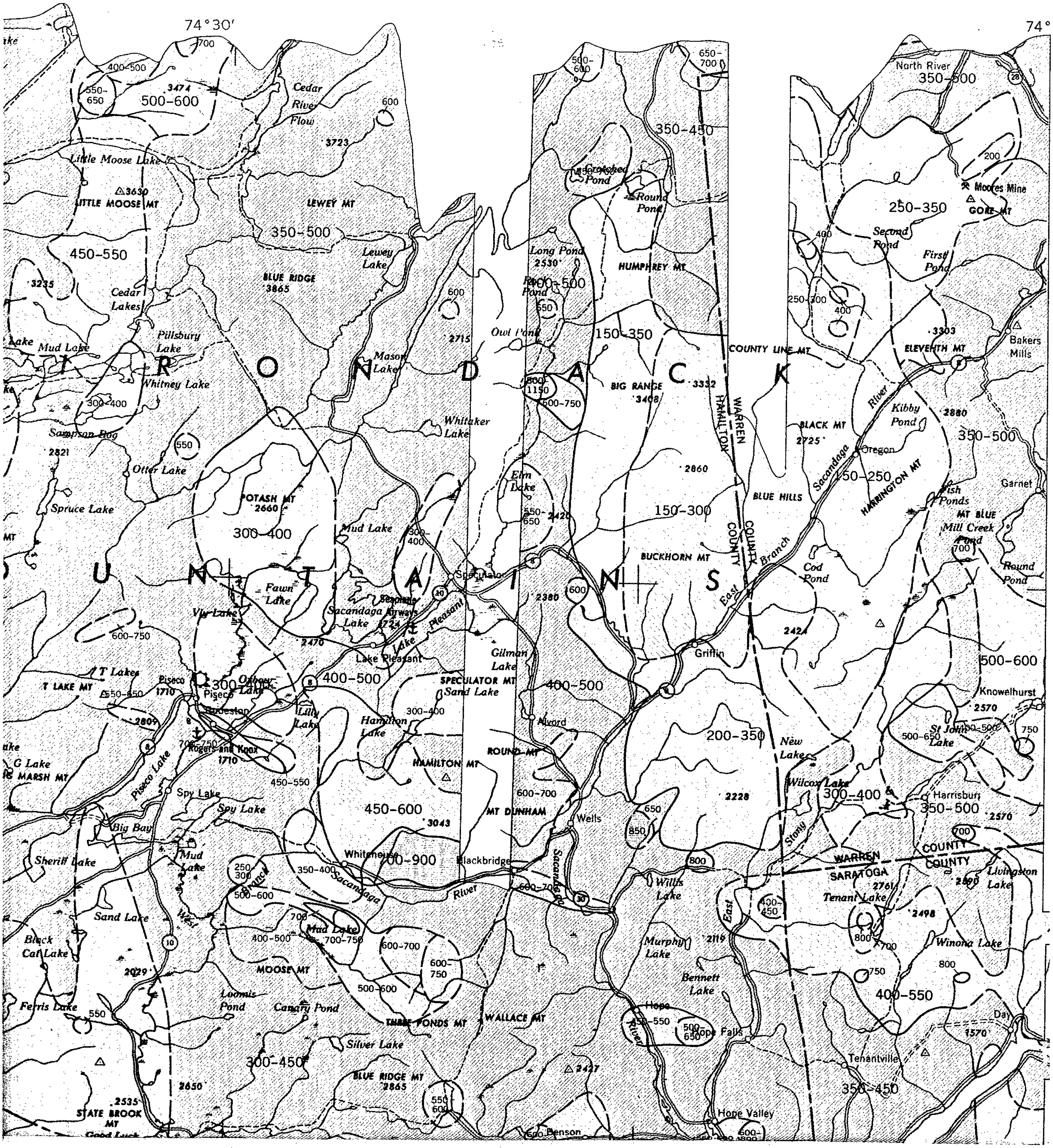

74°30′
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ADIRONDACK
MOUNTAINS
Cedar River Flow
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LITTLE MOOSE MT
LEWEY MT
Lewey Lake
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Cedar Lakes
Pillsbury Lake
Mud Lake
Whitney Lake
Mason Lake
Whitaker Lake
Sampson Bog
Otter Lake
POTASH MT 2660
Spruce Lake
Mud Lake
Fawn Lake
Vly Lake
Sacandaga Airways
Lake Pleasant
T Lakes
T LAKE MT
Piseco
Piseco Lake
Oxbow Lake
Rudeston
Rogers and Knox
Lilly Lake
Hamilton Lake
HAMILTON MT
SPECULATOR MT
Sand Lake
Speculator
Gilman Lake
Alvord
ROUND MT
MT DUNHAM
Wells
Whitehouse
Blackbridge
Sacandaga River
West Branch
Spy Lake
Big Bay
Sheriff Lake
Mud Lake
Sand Lake
Black Cat Lake
Ferris Lake
Loomis Pond
Canary Pond
MOOSE MT
THREE PONDS MT
WALLACE MT
Silver Lake
BLUE RIDGE MT 2865
STATE BROOK MT
Benson
Crotched Pond
Round Pond
Long Pond
HUMPHREY MT
Owl Pond
Elm Lake
BIG RANGE 3408
BUCKHORN MT
COUNTY LINE MT
HAMILTON COUNTY
WARREN COUNTY
Griffin
East Branch
Willis Lake
Murphy Lake
Bennett Lake
Hope
Hope Falls
Hope Valley
North River
Moores Mine
GORE MT
Second Pond
First Pond
Bakers Mills
ELEVENTH MT
BLACK MT
Kibby Pond
Oregon
HARRINGTON MT
BLUE HILLS
Fish Ponds
Garnet
MT BLUE
Mill Creek Pond
Round Pond
Cod Pond
Knowelhurst
St John Lake
New Lake
Wilcox Lake
Harrisburg
SARATOGA
Tenant Lake
Livingston Lake
Winona Lake
Day
Tenantville
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400-500
450-600
700-900
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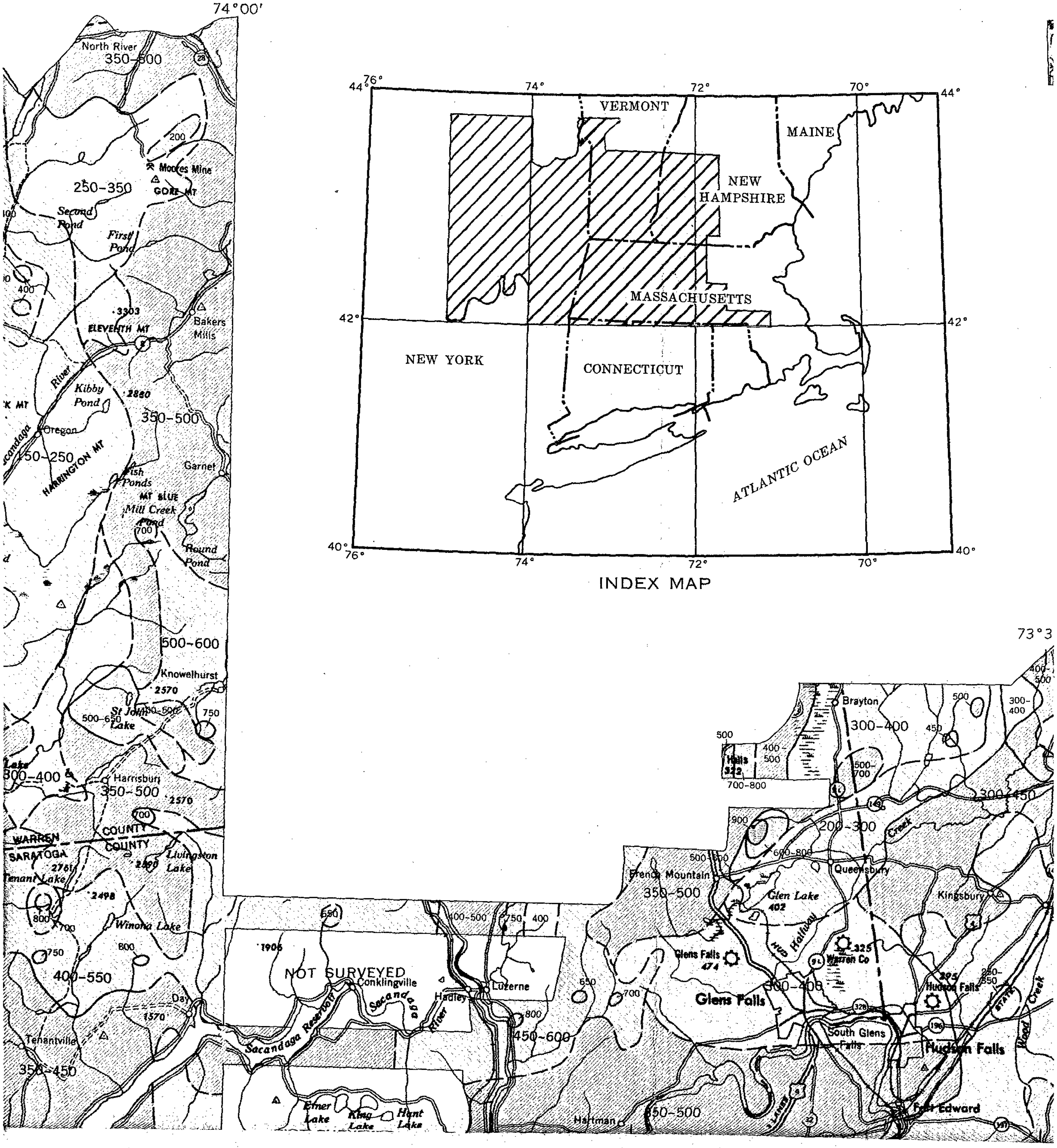

74°00′
North River
350-500
250-350
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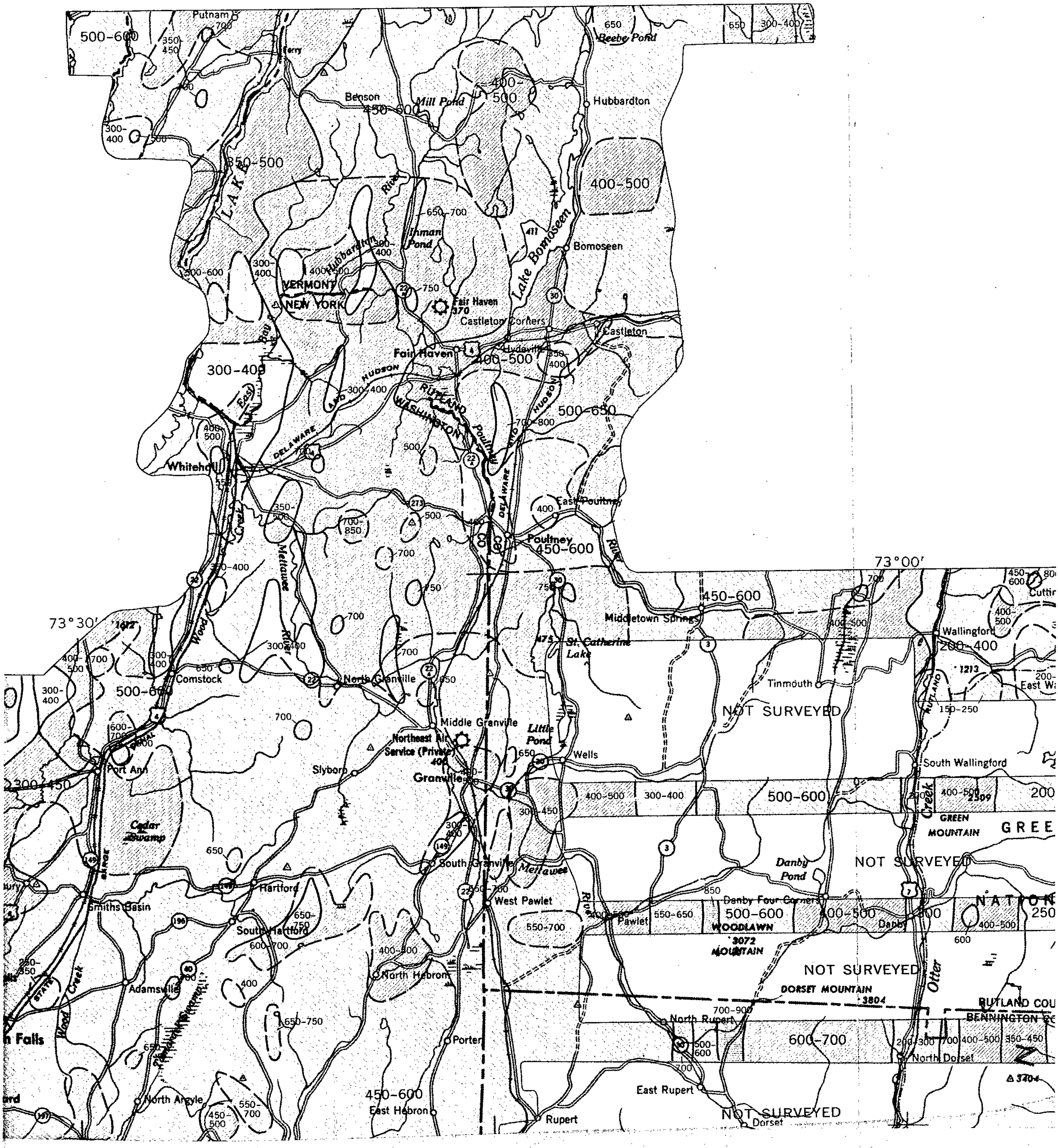
GORE MT
Second Pond
First Pond
ELEVENTH MT
Bakers Mills
Kibby Pond
Oregon
150-250
HARRINGTON MT
350-500
Garnet
Fish Ponds
MT BLUE
Mill Creek Pond
Round Pond
500-600
Knowelhurst
St John Lake
Harrisburg
300-400
350-500
WARREN COUNTY
SARATOGA COUNTY
Livingston Lake
Tenant Lake
Winona Lake
400-550
Day
Tenantville
350-450
NOT SURVEYED
Conklingville
Sacandaga Reservoir
Hadley
Luzerne
450-600
Ebner Lake
King Lake
Hunt Lake
Hartman
350-500
French Mountain
350-500
Glen Lake
Glens Falls
300-400
South Glens Falls
Hudson Falls
Fort Edward
Queensbury
Kingsbury
Brayton
300-400
200-300
300-450
73°3
VERMONT
MAINE
NEW HAMPSHIRE
MASSACHUSETTS
NEW YORK
CONNECTICUT
ATLANTIC OCEAN
76°
74°
72°
70°
44°
42°
40°

INDEX MAP

4

PREPARED IN COOPERATION WITH
DIVISION OF BIOLOGY AND MEDICINE
U.S. ATOMIC ENERGY COMMISSION



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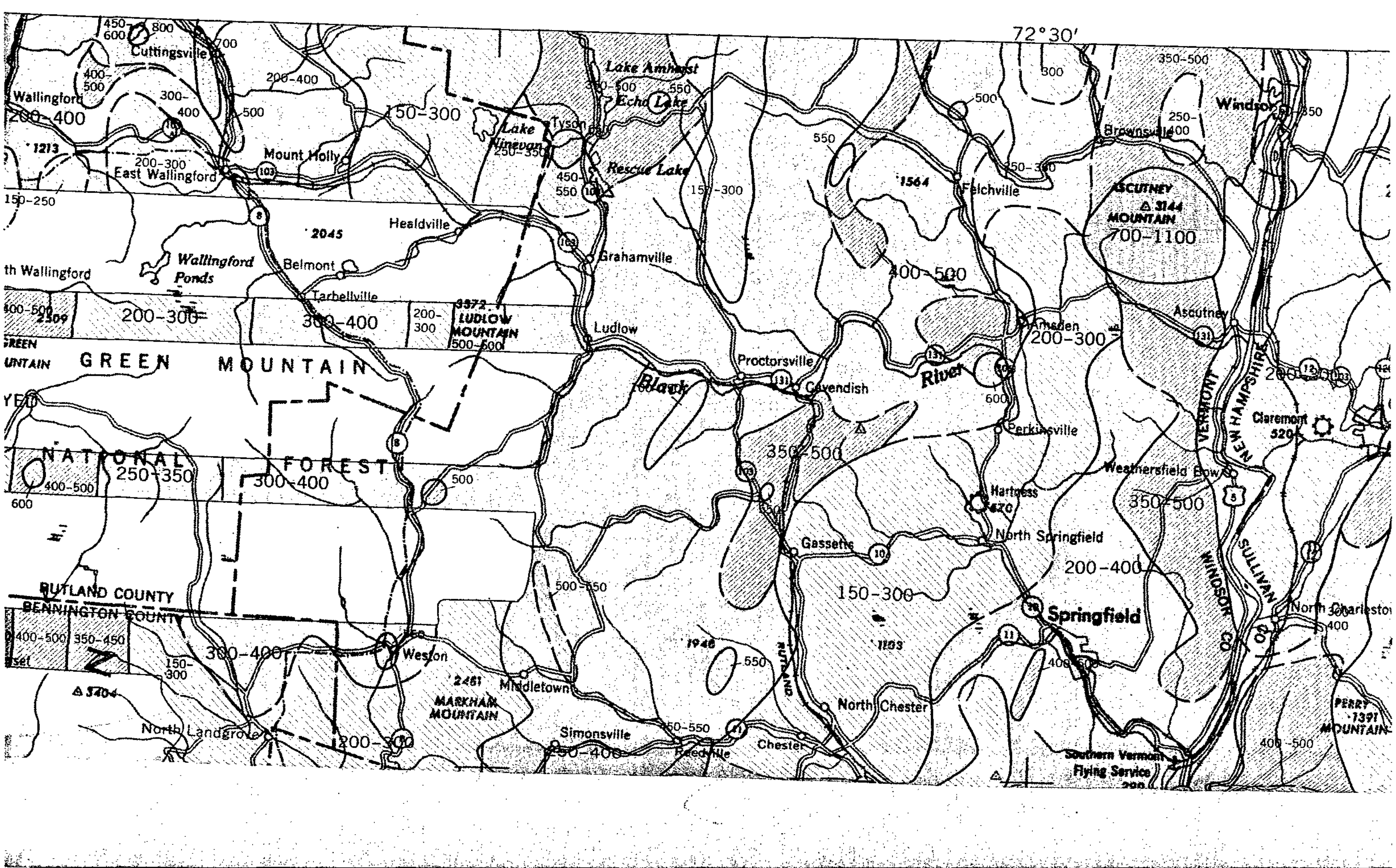
MMISSION

5



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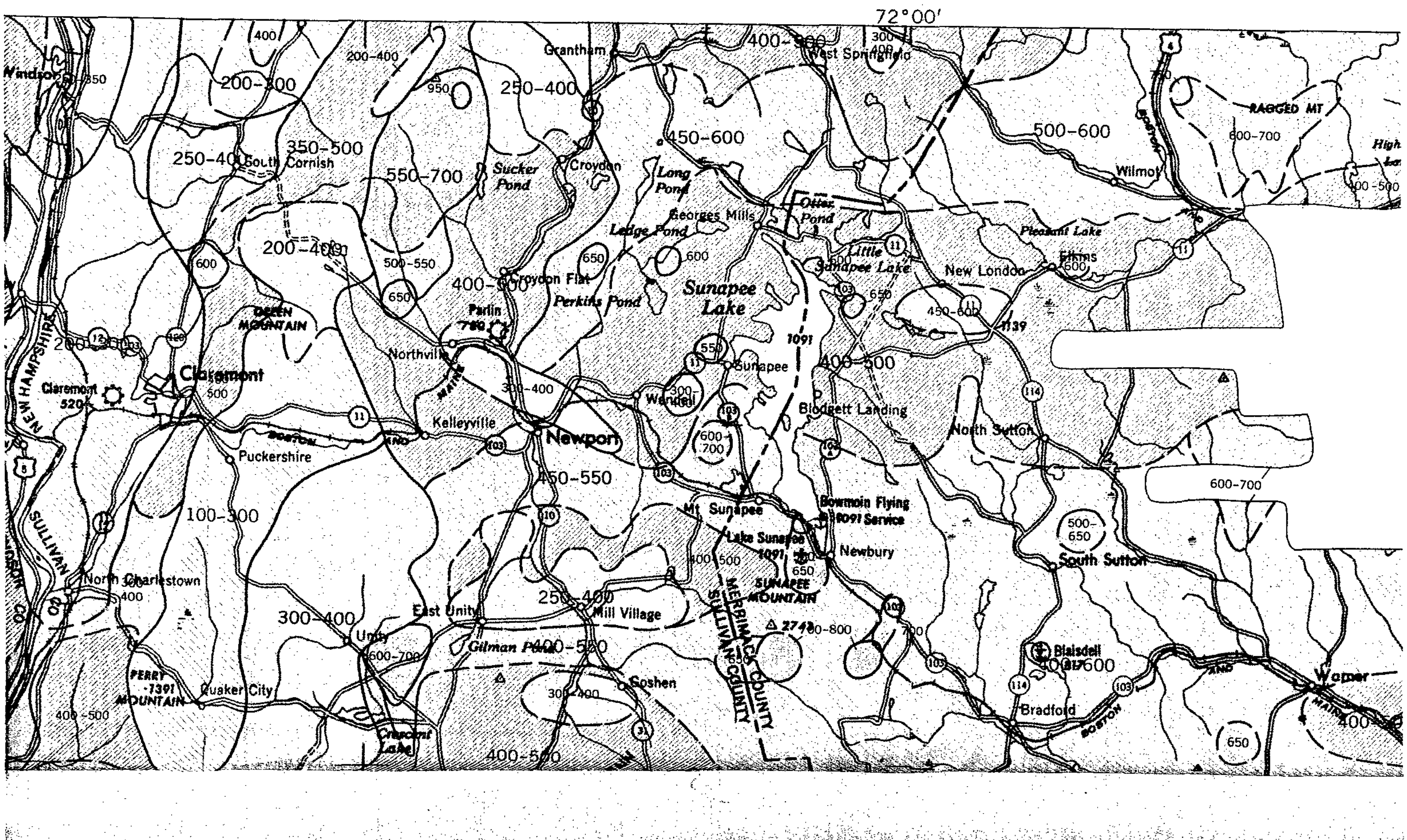
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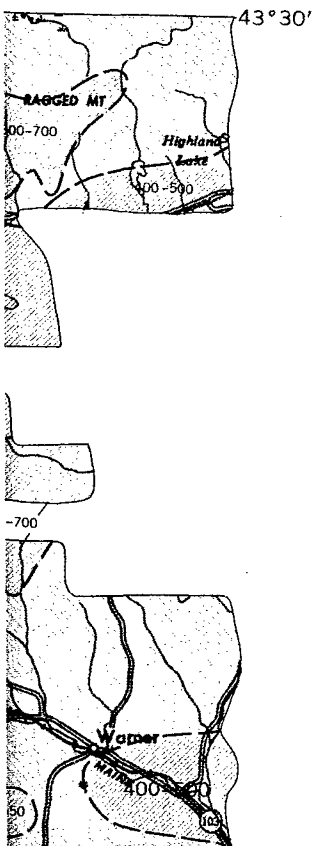
250-400
South Cornish
350-500
550-700
Sucker Pond
Croydon
Long Pond
Georges Mills
Otter Pond
Ledge Pond
Pleasant Lake
Elkins
200-400
500-550
Croydon Flat
400-500
Little Sunapee Lake
New London
Perkins Pond
Sunapee Lake
GREEN MOUNTAIN
Parlin
Northville
Sunapee
400-500
Claremont
Claremont
300-400
Wendell
Blodgett Landing
Kelleyville
Newport
North Sutton
Puckershire
NEW HAMPSHIRE
450-550
600-700
100-300
Mt. Sunapee
Bowmoin Flying
1091 Service
Lake Sunapee
Newbury
500-650
South Sutton
SULLIVAN CO.
North Charlestown
250-400
East Unity
300-400
Mill Village
SUNAPEE MOUNTAIN
MERRIMACK COUNTY
SULLIVAN COUNTY
Unity
Gilman Pond
400-500
Blaisdell
600-700
PERRY MOUNTAIN
Quaker City
Goshen
300-400
Bradford
Warner
400-500
Crescent Lake
400-500
650

7

AI
GEOPHYS



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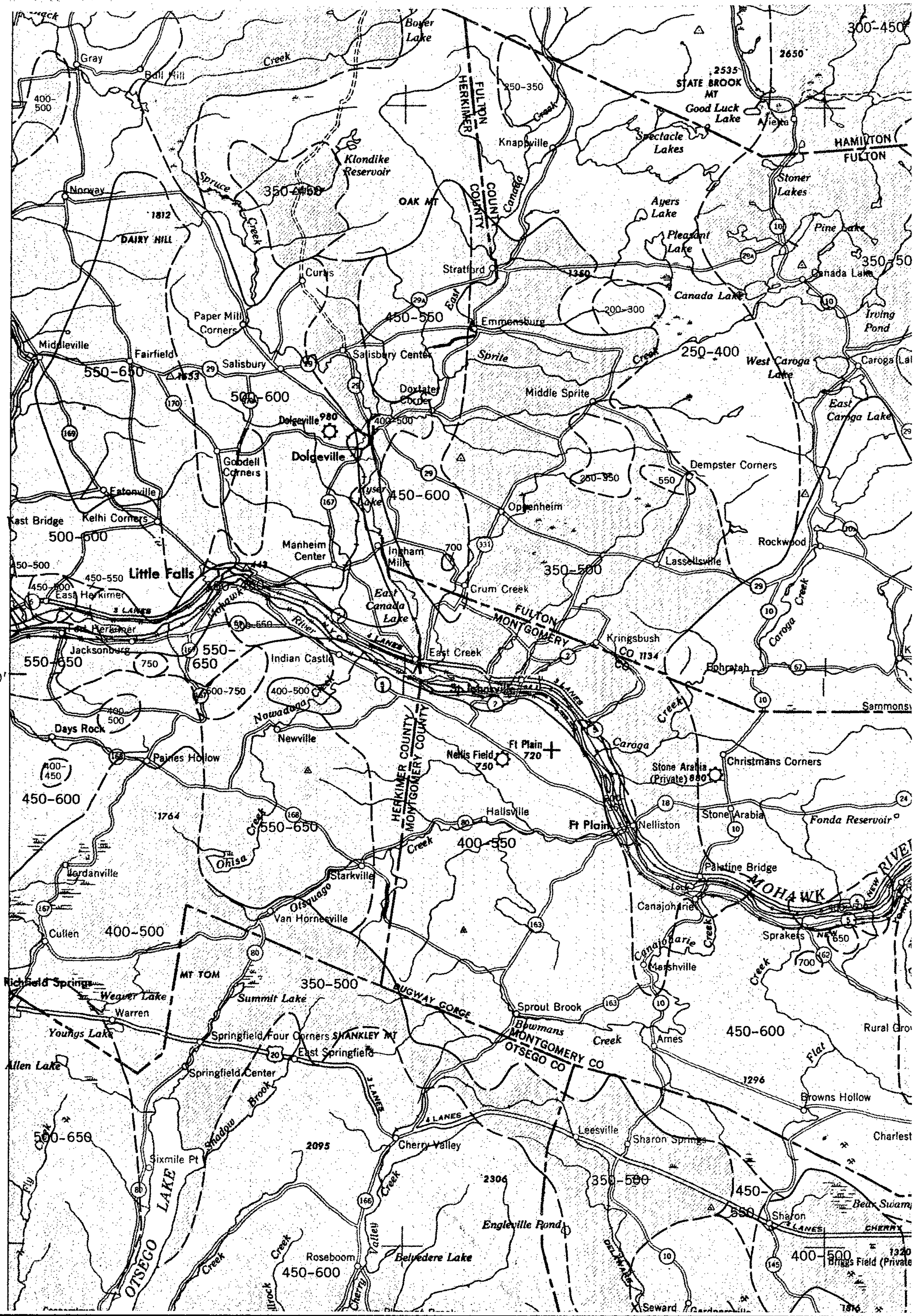
GEOPHYSICAL INVESTIGATIONS

MAP GP-358

8



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Creek
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HERKIMER
250-350
Knappville
Spectacle Lakes
HAMILTON
FULTON
Klondike Reservoir
Spruce Creek
350-450
OAK MT
COUNTY
COUNTY
Canada
Stoner Lakes
Norway
1812
DAIRY HILL
Ayers Lake
Pleasant Lake
Pine Lake
Curtis
Stratford
1350
Canada Lake
350-50
200-300
Irving Pond
Paper Mill Corners
450-550
Emmonsburg
East
Middleville
Fairfield
Salisbury
Salisbury Center
Sprite
Creek
250-400
West Caroga Lake
550-650
1633
500-600
Dolgeville
Middle Sprite
East Caroga Lake
400-500
Dolgeville
Goodell Corners
Dempster Corners
Eatonville
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250-350
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Kast Bridge
Kelhi Corners
Oppenheim
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Manheim Center
Ingham Mills
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Rockwood
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Little Falls
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Lassellsville
East Herkimer
Mohawk
East Canada Lake
Crum Creek
FULTON
MONTGOMERY
Ft Herkimer
River
Kringsbush
CO 1134
Caroga Creek
Jacksonburg
550-650
550-650
750
Indian Castle
East Creek
Ephratah
43°00'
600-750
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St Johnsville
Sammons
400-500
Days Rock
Nowadaga Creek
Newville
Caroga
Creek
Ft Plain 720
Nellis Field 750
HERKIMER COUNTY
MONTGOMERY COUNTY
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Christmans Corners
Stone Arabia (Private) 880
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450-600
1764
Creek
550-650
Hallsville
Ft Plain
Nelliston
Stone Arabia
Fonda Reservoir
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Creek
Ohisa
Jordanville
Starkville
Palatine Bridge
MOHAWK
RIVER
Otsquago
Canajoharie
Van Hornesville
Cullen
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Sprakers
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Canajoharie Creek
Marshville
700
Creek
MT TOM
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Weaver Lake
Summit Lake
BUGWAY GORGE
Sprout Brook
Warren
Bowmans Creek
Youngs Lake
Springfield Four Corners
SHANKLEY MT
MONTGOMERY CO
OTSEGO CO
Ames
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Rural Gro
East Springfield
Flat
Allen Lake
Springfield Center
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Browns Hollow
Shadow Brook
Leesville
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2095
Cherry Valley
Sharon Springs
Charlest
Sixmile Pt
OTSEGO LAKE
2306
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450-
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Fly Creek
Creek
Valley
Englevile Pond
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Sharon
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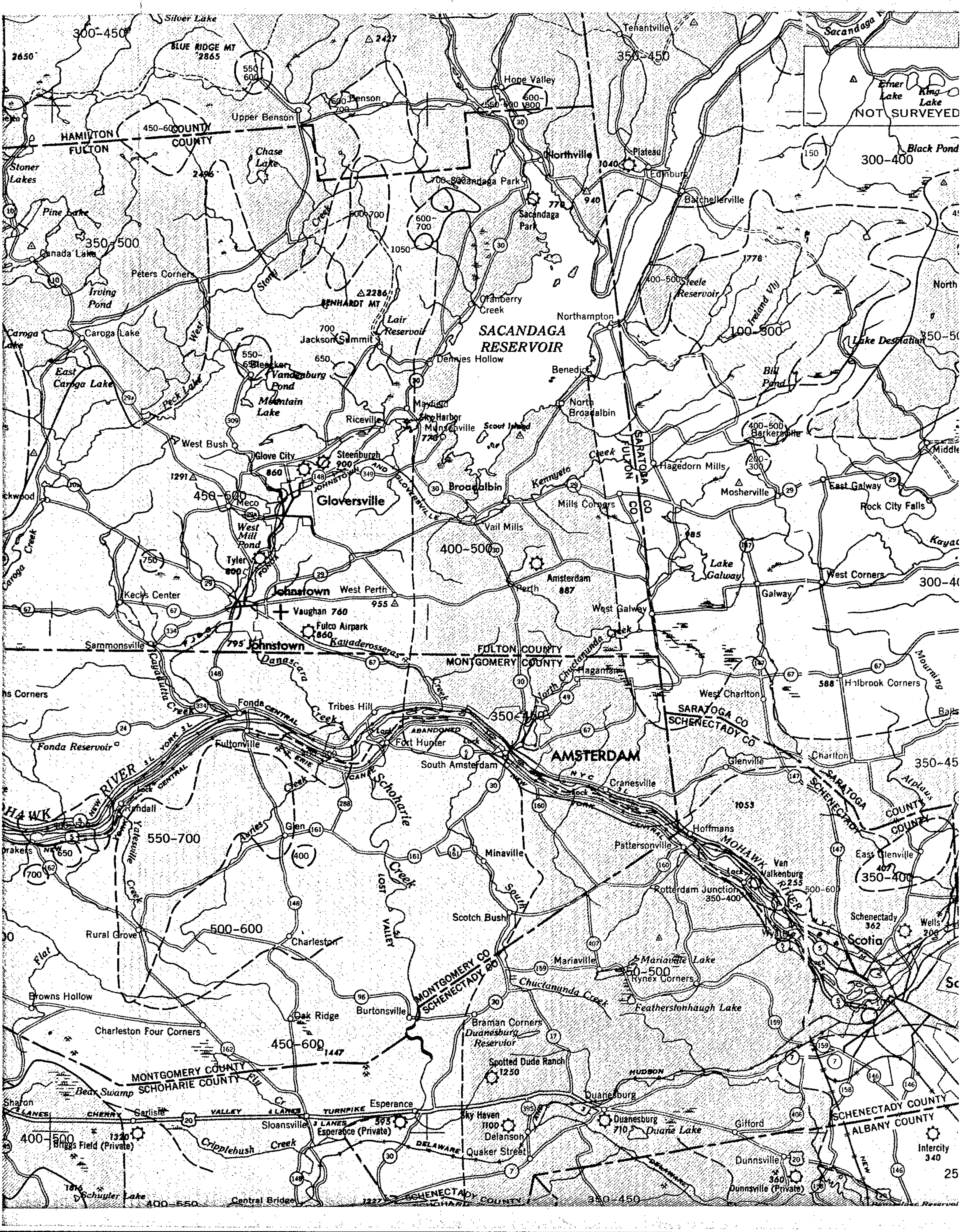
Seward
1816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Sacandaga
Efner Lake
King Lake
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FULTON COUNTY
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Northville
Plateau
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Sacandaga Park
770
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Batchellerville
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Canada Lake
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Ireland Vly
North
Caroga Lake
West
Jackson Summit
Lair Reservoir
Northampton
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Mountain Lake
Peck Lake
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Dennies Hollow
Benedict
Bill Pond
Mayfield
North Broadalbin
Riceville
Sky Harbor
Munsonville
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West Bush
Glove City
Steenburgh
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FULTON CO
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Broadalbin
Kennyetto Creek
Mosherville
East Galway
Rock City Falls
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Meco
Gloversville
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Mills Corners
Vail Mills
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Tyler
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West Corners
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Amsterdam
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Kecks Center
Johnstown
West Perth
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Perth
Galway
Vaughan 760
Fulco Airpark
860
West Galway
Sammonsville
795
Johnstown
Kayaderosseras
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MONTGOMERY COUNTY
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Hagaman
Mourning
Cayadutta Creek
North Chuctanunda Creek
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Holbrook Corners
Fonda
Tribes Hill
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Fultonville
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Fort Hunter
South Amsterdam
AMSTERDAM
Charlton
Glenville
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RIVER
ERIE CANAL
Schoharie
Cranesville
N Y C
Randall
MOHAWK
550-700
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SARATOGA COUNTY
SCHENECTADY COUNTY
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Auries
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MOHAWK RIVER
Van Walkenburg
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Rural Grove
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SCHENECTADY CO
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Chuctanunda Creek
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Oak Ridge
Burtonsville
Braman Corners
Duanesburg Reservoir
Charleston Four Corners
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MONTGOMERY COUNTY
SCHOHARIE COUNTY
HUDSON
Bear Swamp
Fly Cr
Duanesburg
Sharon
Carlisle
CHERRY
VALLEY
TURNPIKE
Esperance
595
Sloansville
Esperance (Private)
Sky Haven
1100
Delanson
Duanesburg
710
Duane Lake
Gifford
SCHENECTADY COUNTY
ALBANY COUNTY
400-500
1320
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Cripplebush Creek
DELAWARE
Quaker Street
Intercity
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SCHOHARIE COUNTY
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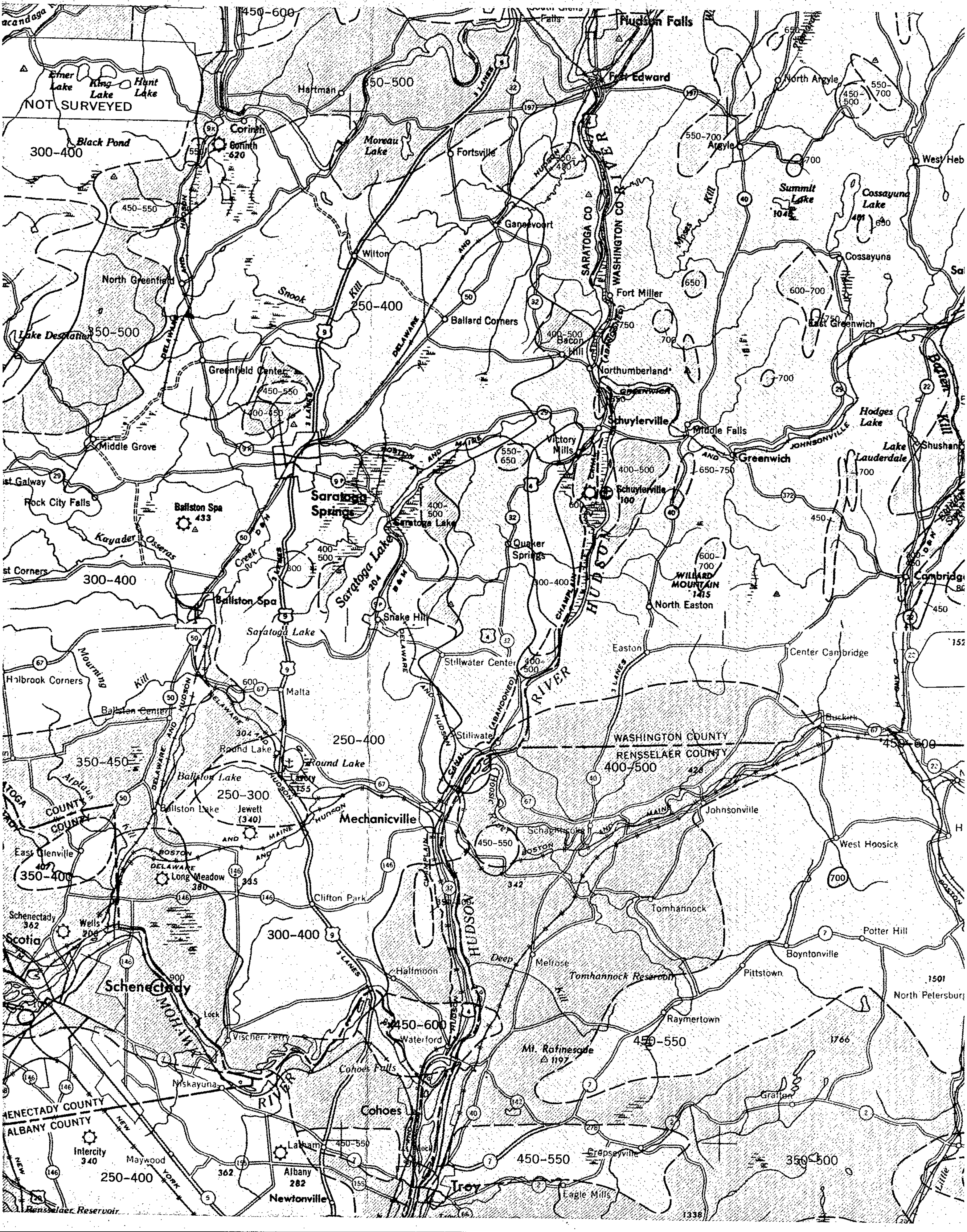
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Hartman
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Argyle
West Hebron
Summit Lake
Cossayuna Lake
Cossayuna
Gansevoort
Wilton
North Greenfield
Lake Desolation
Ballard Corners
Fort Miller
Bacon Hill
East Greenwich
Northumberland
Greenfield Center
Schuylerville
Middle Falls
Greenwich
Hodges Lake
Lake Lauderdale
Shushan
Middle Grove
Victory Mills
Rock City Falls
Saratoga Springs
Saratoga Lake
Ballston Spa
Kayaderosseras Creek
Quaker Springs
Willard Mountain 1415
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Snake Hill
North Easton
Easton
Center Cambridge
Stillwater Center
Holbrook Corners
Mourning Kill
Malta
Ballston Center
Buskirk
Stillwater
Round Lake
WASHINGTON COUNTY
RENSSELAER COUNTY
Ballston Lake
Jewett (340)
Mechanicville
Johnsonville
East Glenville
Long Meadow
Schaghticoke
West Hoosick
Clifton Park
Tomhannock
Schenectady
Scotia
Potter Hill
Boyntonville
Halfmoon
Melrose
Tomhannock Reservoir
Pittstown
North Petersburg
Raymertown
Waterford
Mt. Rafinesque 1197
Vischer Ferry
Niskayuna
Cohoes Falls
MOHAWK RIVER
HUDSON RIVER
Grafton
Cohoes
SCHENECTADY COUNTY
ALBANY COUNTY
Intercity 340
Maywood
Latham
Albany 282
Newtonville
Troy
Eagle Mills
Cropseyville
Rensselaer Reservoir
SARATOGA CO
WASHINGTON CO
300-400
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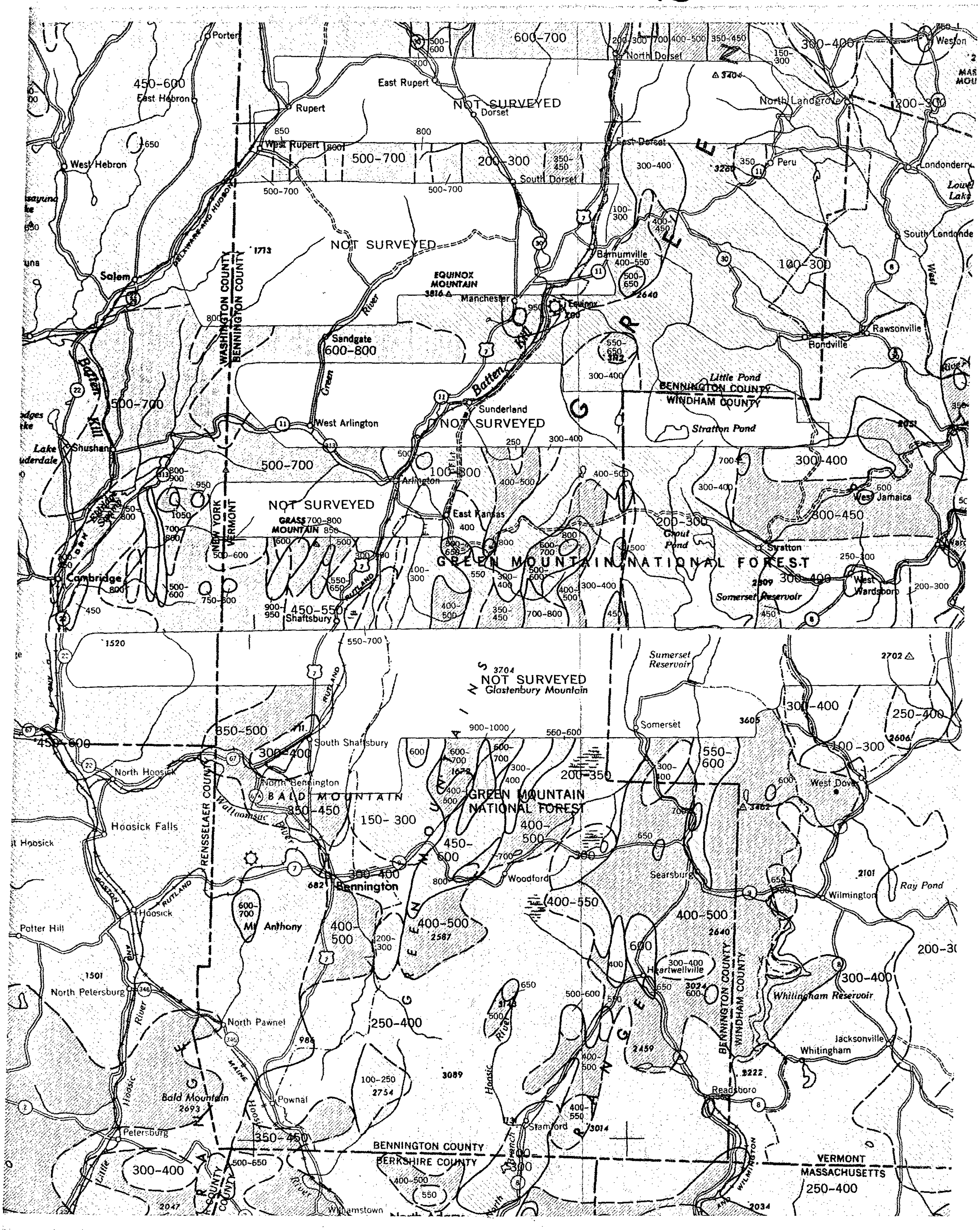

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Glastenbury Mountain
GREEN MOUNTAIN NATIONAL FOREST
GREEN MOUNTAIN NATIONAL FOREST
BALD MOUNTAIN
EQUINOX MOUNTAIN
GRASS MOUNTAIN
WASHINGTON COUNTY
BENNINGTON COUNTY
NEW YORK
VERMONT
RENSSELAER COUNTY
BENNINGTON COUNTY
WINDHAM COUNTY
BERKSHIRE COUNTY
VERMONT
MASSACHUSETTS
Porter
East Hebron
West Hebron
Salem
Shushan
Cambridge
Rupert
West Rupert
East Rupert
Dorset
North Dorset
East Dorset
South Dorset
Peru
North Landgrove
Weston
Londonderry
South Londonderry
Barnumville
Manchester
Equinox
Sandgate
Bondville
Rawsonville
Sunderland
West Arlington
Arlington
East Kansas
Little Pond
Stratton Pond
Grout Pond
Stratton
West Jamaica
West Wardsboro
Somerset Reservoir
Sumerset Reservoir
Somerset
Shaftsbury
South Shaftsbury
North Hoosick
North Bennington
Hoosick Falls
Hoosick
Bennington
Woodford
Searsburg
West Dover
Wilmington
Ray Pond
Mt Anthony
Potter Hill
North Petersburg
North Pownal
Pownal
Petersburg
Bald Mountain
Heartwellville
Whitingham Reservoir
Jacksonville
Whitingham
Readsboro
Stamford
Williamstown
Batten Kill
Green River
Walloomsac
Hoosic River
Little Hoosic
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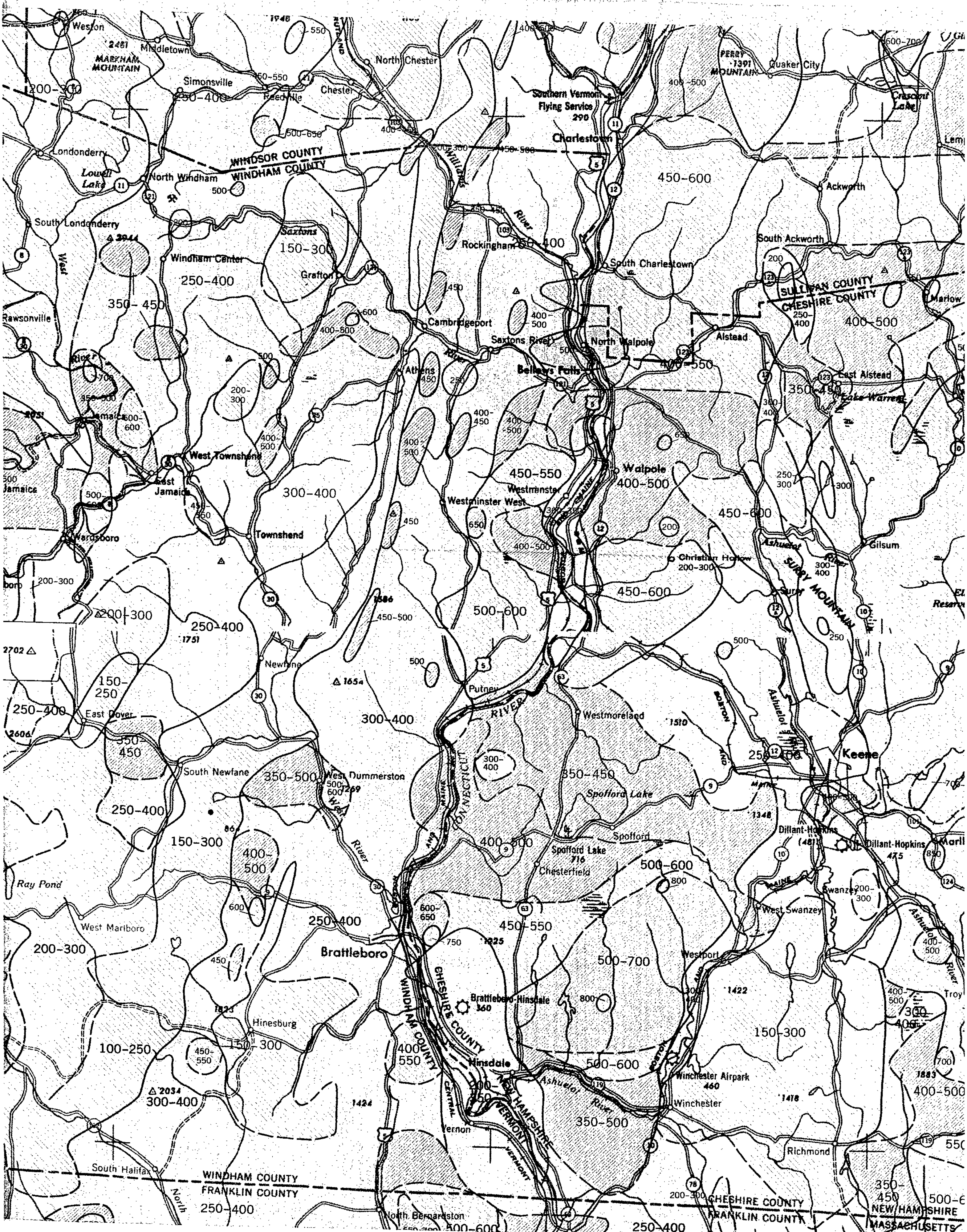
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Chester
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Southern Vermont Flying Service
Charlestown
PERRY MOUNTAIN
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Crescent Lake
Londonderry
Lowell Lake
North Windham
WINDSOR COUNTY
WINDHAM COUNTY
Ackworth
South Londonderry
Saxtons
Rockingham
South Charlestown
South Ackworth
Windham Center
Grafton
SULLIVAN COUNTY
CHESHIRE COUNTY
Marlow
Rawsonville
Cambridgeport
Saxtons River
North Walpole
Alstead
Athens
Bellows Falls
East Alstead
Lake Warren
Jamaica
West Townshend
Walpole
East Jamaica
Westminster
Westminster West
Townshend
Wardsboro
Christian Hollow
Gilsum
SURRY MOUNTAIN
Newfane
Putney
Westmoreland
East Dover
South Newfane
West Dummerston
Keene
Spofford Lake
Spofford
Dillant-Hopkins
Chesterfield
Swanzey
Ray Pond
West Marlboro
West Swanzey
Brattleboro
Westport
Brattleboro-Hinsdale
Hinesburg
Hinsdale
Winchester Airpark
Winchester
Vernon
Richmond
South Halifax
CHESHIRE COUNTY
WINDHAM COUNTY
VERMONT
NEW HAMPSHIRE
CONNECTICUT RIVER
WINDHAM COUNTY
FRANKLIN COUNTY
CHESHIRE COUNTY
FRANKLIN COUNTY
NEW HAMPSHIRE
MASSACHUSETTS
North Bernardston
450-600
150-300
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400-500
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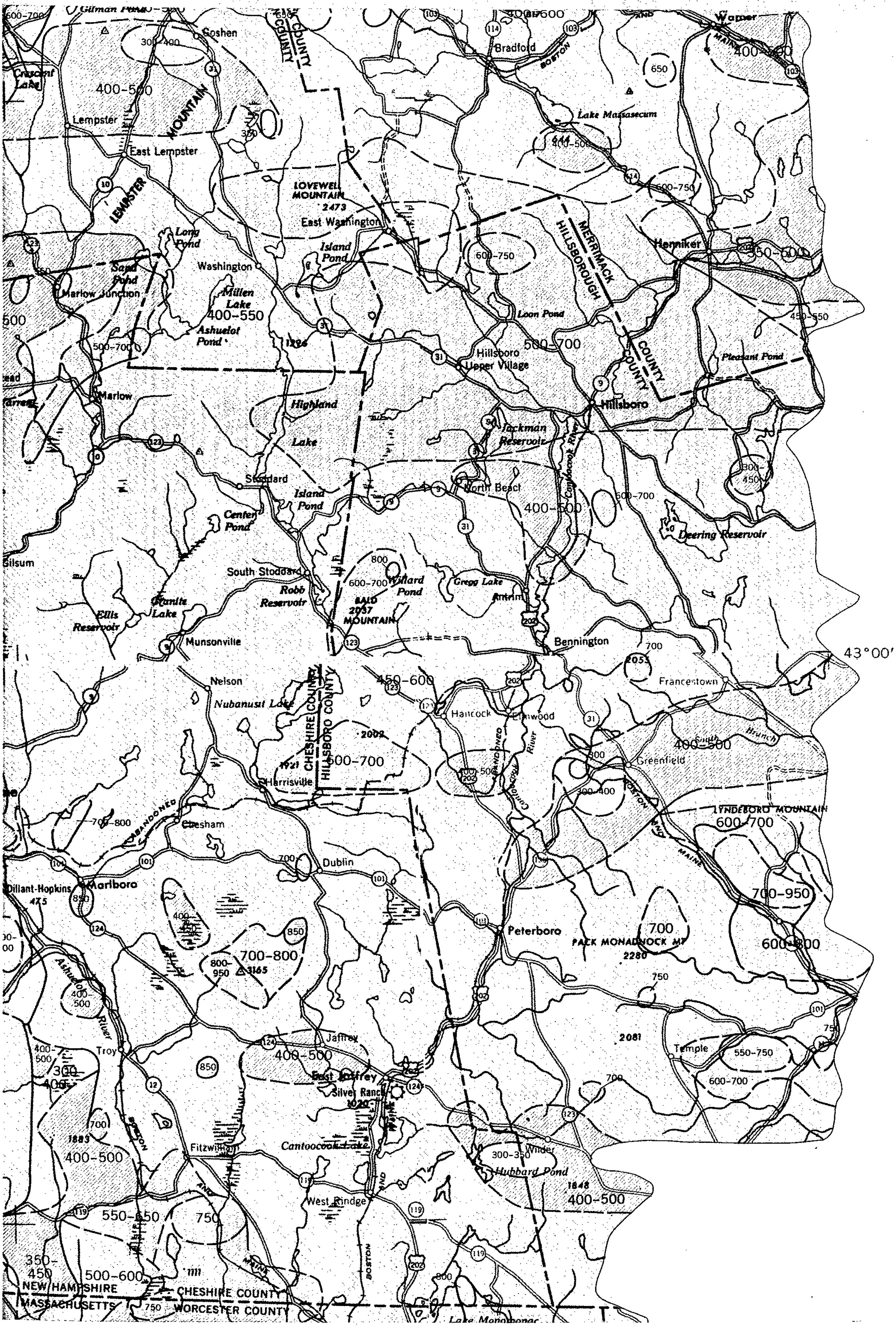
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Warner
Crescent Lake
400-500
Lempster
MOUNTAIN
East Lempster
LEMPSTER
Lake Massasecum
LOVEWELL MOUNTAIN
2473
East Washington
Long Pond
Washington
Island Pond
600-750
MERRIMACK
HILLSBOROUGH
Henniker
Sand Pond
Marlow Junction
Millen Lake
400-550
Ashuelot Pond
Loon Pond
450-550
500-700
COUNTY
Hillsboro Upper Village
Pleasant Pond
Marlow
Highland
Lake
Hillsboro
Jackman Reservoir
Contoocook River
Stoddard
Island Pond
North Beach
400-500
600-700
Center Pond
Deering Reservoir
Gilsum
South Stoddard
600-700
Willard Pond
Gregg Lake
Antrim
Robb Reservoir
BALD 2037 MOUNTAIN
Granite Lake
Ellis Reservoir
Munsonville
Bennington
700
43°00'
Nelson
450-600
Francestown
Nubanusit Lake
CHESHIRE COUNTY
HILLSBORO COUNTY
Hancock
Elmwood
2002
600-700
400-500
Greenfield
Harrisville
300-400
LYNDEBORO MOUNTAIN
600-700
700-800
Chesham
Dublin
MAINE
Dillant-Hopkins 475
Marlboro
700-950
Peterboro
700
PACK MONADNOCK MT 2280
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Jaffrey
Troy
2081
Temple
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Silver Ranch
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Fitzwilliam
300-350
Wilder
Hubbard Pond
1883
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West Rindge
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750
BOSTON
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NEW HAMPSHIRE
MASSACHUSETTS
CHESHIRE COUNTY
WORCESTER COUNTY

43°00'

The radioactivity data was obtained with scintillation detection equipment (Davis and Reinhardt, 1957) installed in a twin-engine aircraft. Parallel flight traverses were oriented east-west except in the area west of Albany, N. Y., where they were oriented north-south, and flown at one-mile intervals at a nominal elevation of 500 feet above the ground. The radioactivity data were compensated for deviations from the surveying elevation, and for the cosmic-ray component. The flight path of the aircraft was recorded by a gyrostabilized continuous-strip-film camera.

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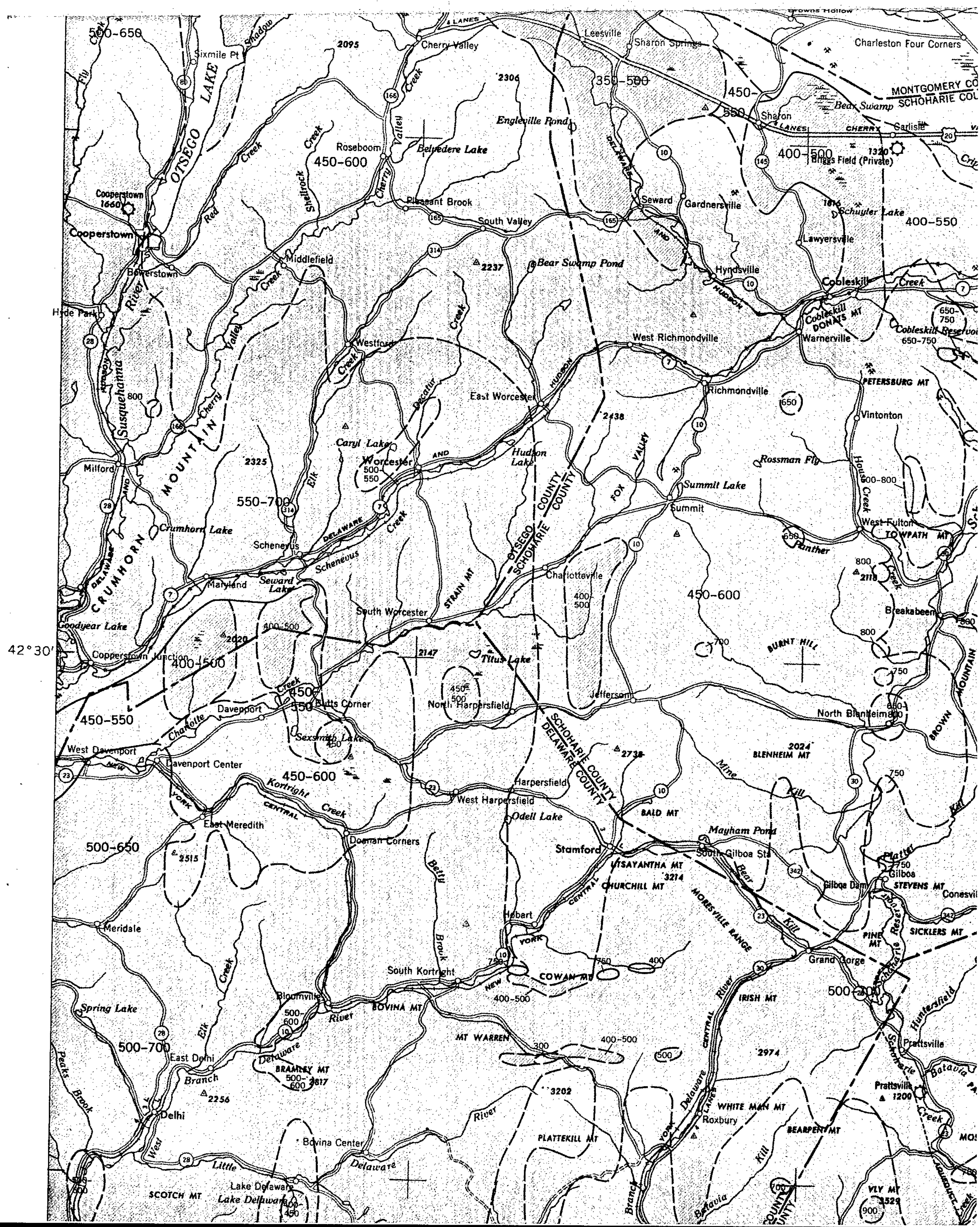
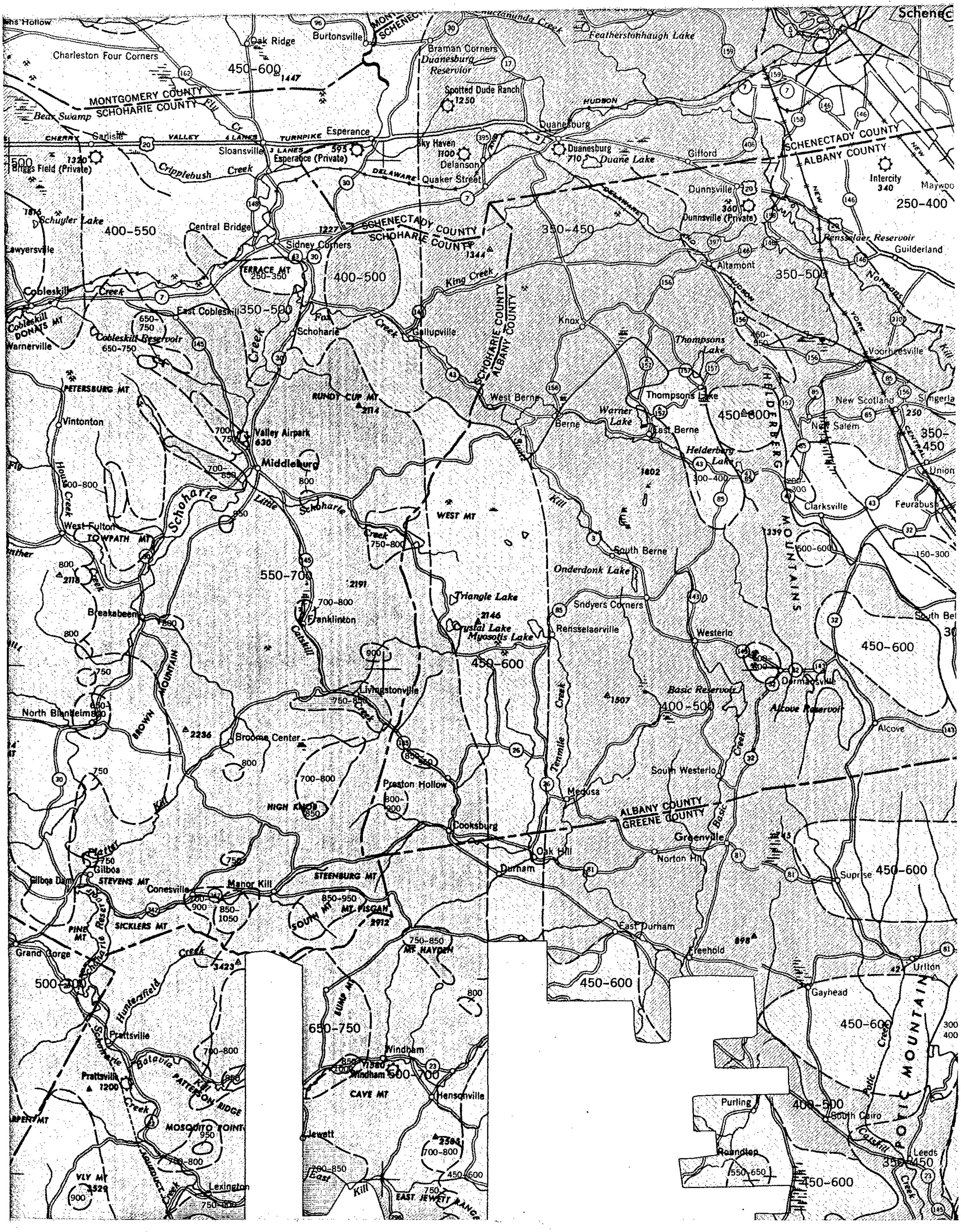
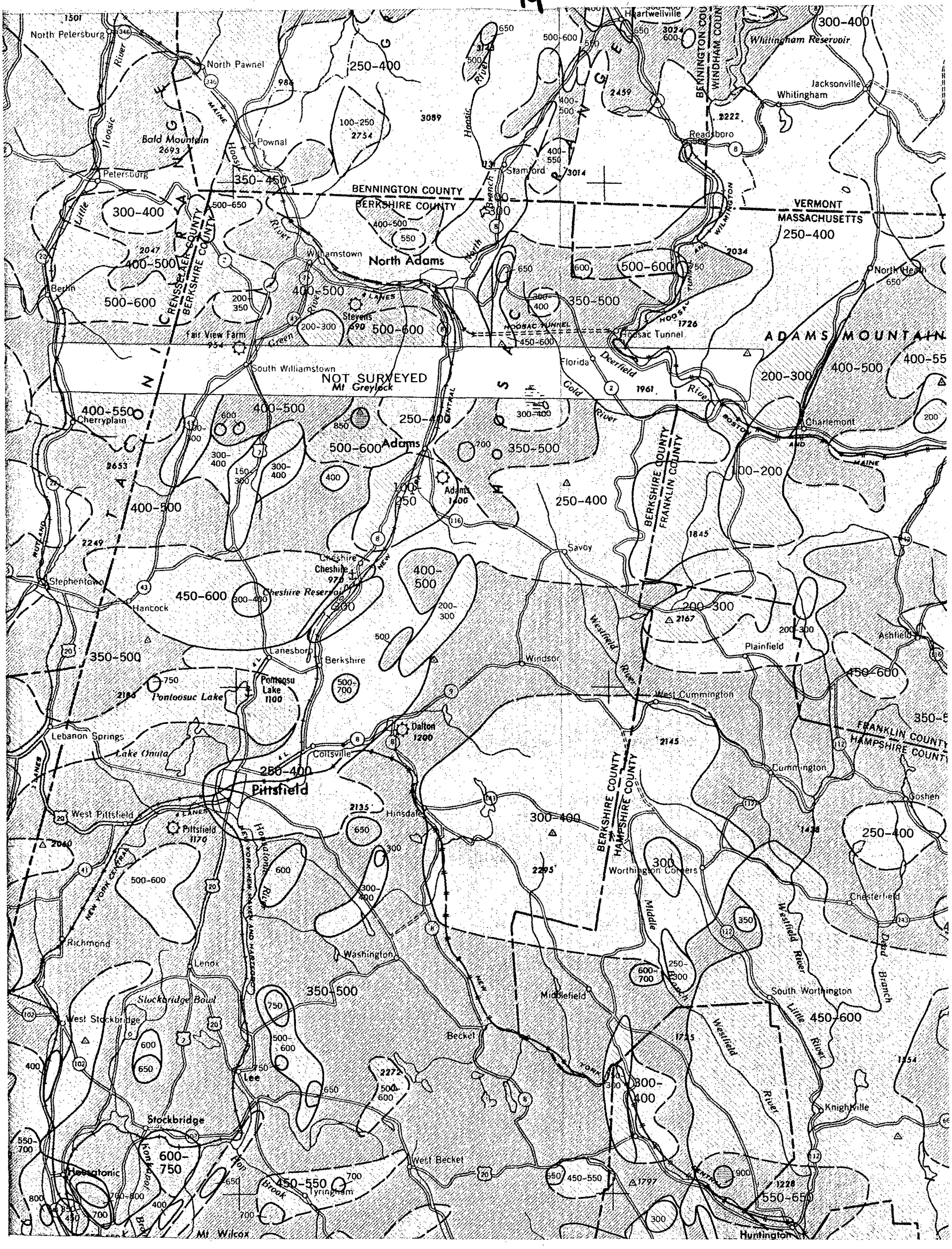
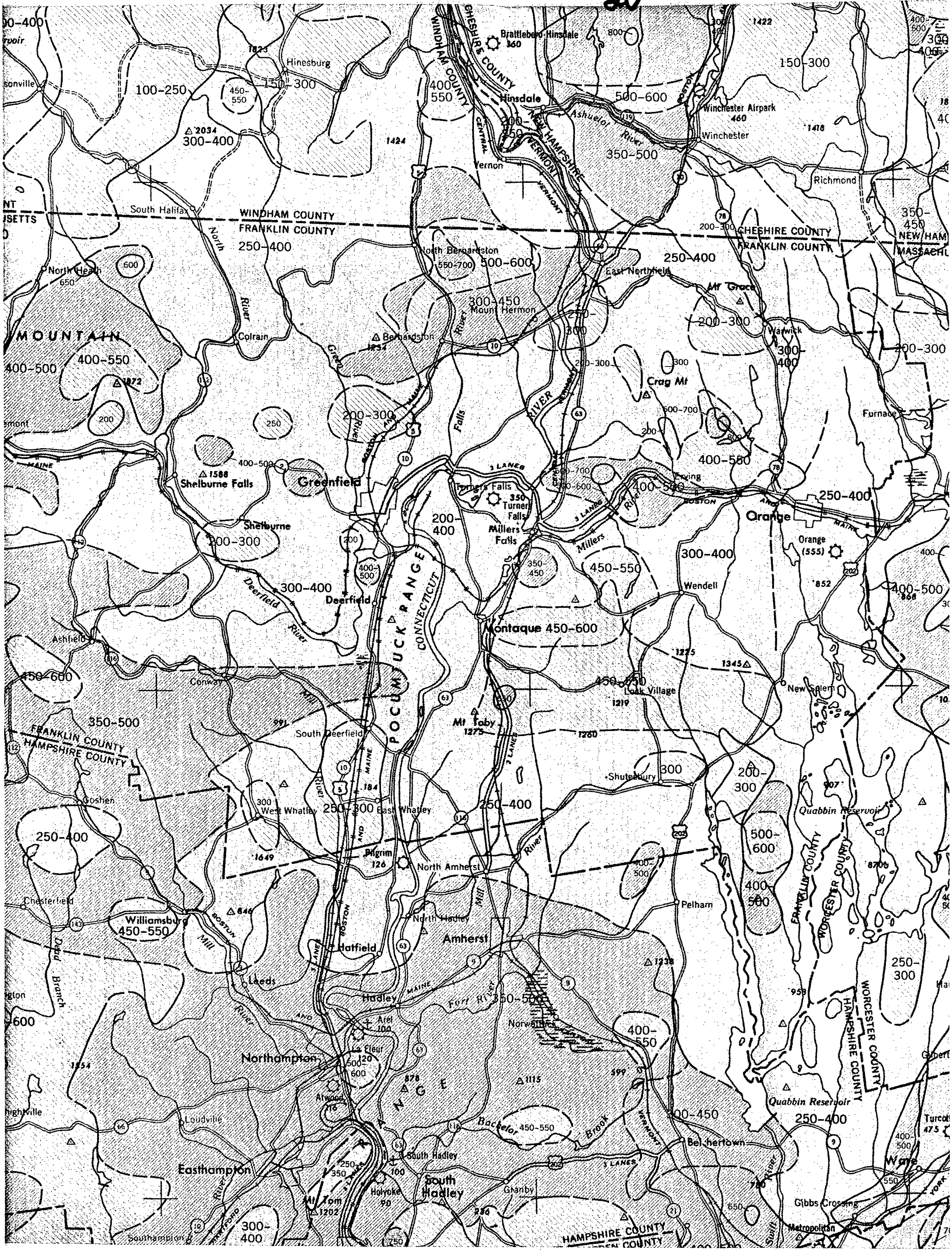

42°30'
Cherry Valley
Leesville
Sharon Springs
Charleston Four Corners
MONTGOMERY CO
SCHOHARIE CO
Bear Swamp
Sharon
Carlisle
Briggs Field (Private)
Sixmile Pt
OTSEGO LAKE
Engleville Pond
Belvedere Lake
Roseboom
450-600
350-500
400-500
500-650
Cooperstown
Cooperstown 1660
Pleasant Brook
South Valley
Seward
Gardnersville
Schuyler Lake
400-550
Lawyersville
Middlefield
Bowerstown
Bear Swamp Pond
Hyndsville
Cobleskill
Cobleskill Reservoir
650-750
DONATS MT
Warnerville
Hyde Park
Westford
West Richmondville
Richmondville
PETERSBURG MT
Vintonton
East Worcester
Susquehanna River
Cherry Valley
MOUNTAIN
Caryl Lake
Worcester
Hudson Lake
Rossman Fly
Summit Lake
Summit
Milford
550-700
Crumhorn Lake
CRUMHORN
Schenevus
Schenevus Creek
Maryland
Seward Lake
OTSEGO COUNTY
SCHOHARIE COUNTY
Charlotteville
450-600
West Fulton
TOWPATH MT
Panther
Breakabeen
Goodyear Lake
South Worcester
STRAIN MT
Copperstown Junction
400-500
Titus Lake
BURNT HILL
Jefferson
450-550
Davenport
Butts Corner
North Harpersfield
North Blenheim
Sexsmith Lake
West Davenport
Davenport Center
BLENHEIM MT
BROWN MOUNTAIN
SCHOHARIE COUNTY
DELAWARE COUNTY
Kortright Creek
Harpersfield
West Harpersfield
Odell Lake
BALD MT
Mine Kill
East Meredith
Doonan Corners
Stamford
Mayham Pond
South Gilboa Sta
500-650
UTSAYANTHA MT
CHURCHILL MT
MORESVILLE RANGE
Gilboa
Gilboa Dam
STEVENS MT
Conesville
Meridale
Betty Brook
Hobart
PINE MT
SICKLERS MT
Grand Gorge
South Kortright
COWAN MT
Bloomville
BOVINA MT
IRISH MT
Spring Lake
MT WARREN
Prattsville
500-700
East Delhi
BRAMLEY MT
Delaware River
Delhi
WHITE MAN MT
Roxbury
BEARPEN MT
Bovina Center
PLATTEKILL MT
Little Delaware
Lake Delaware
SCOTCH MT
Batavia Kill
VLY MT
Peaks Brook
West Branch
Schoharie Creek


Schenec
Charleston Four Corners
Oak Ridge
Burtonsville
Braman Corners
Duanesburg Reservoir
Featherstonhaugh Lake
450-600
1447
MONTGOMERY COUNTY
SCHOHARIE COUNTY
Bear Swamp
Spotted Dude Ranch
1250
Carlisle
Esperance
Sloansville
Esperance (Private)
595
Sky Haven
1100
Delanson
Quaker Street
Duanesburg
Duanesburg
710
Duane Lake
Gifford
SCHENECTADY COUNTY
ALBANY COUNTY
Intercity
340
250-400
Briggs Field (Private)
1320
Cripplebush Creek
Schuyler Lake
400-550
Central Bridge
Sidney Corners
1227
SCHENECTADY COUNTY
SCHOHARIE COUNTY
1344
350-450
Dunnsville
360
Dunnsville (Private)
Rensselaer Reservoir
Guilderland
Altamont
350-500
Lawyersville
TERRACE MT
250-350
400-500
King Creek
Cobleskill
East Cobleskill
350-500
Schoharie
Gallupville
Knox
Thompsons Lake
Cobleskill Reservoir
650-750
Warnerville
SCHOHARIE COUNTY
ALBANY COUNTY
Voorheesville
PETERSBURG MT
RUNDY CUP MT
2114
West Berne
Berne
Thompsons Lake
Warner Lake
East Berne
450-600
New Scotland
New Salem
Vintonton
Valley Airpark
630
Middleburg
Helderberg Lake
HELDERBERG MOUNTAINS
1802
300-400
Clarksville
Feurabush
Union
Little Schoharie Creek
WEST MT
West Fulton
TOWPATH MT
South Berne
1339
500-600
150-300
2110
550-700
2191
Onderdonk Lake
Triangle Lake
2146
Sndyers Corners
Franklinton
700-800
Breakabeen
Crystal Lake
Myosotis Lake
Rensselaerville
Westerlo
450-600
Catskill
450-600
Basic Reservoir
1507
400-500
Alcove Reservoir
Dormansville
Livingstonville
750-850
North Blenheim
BROWN MOUNTAIN
2236
Broome Center
Alcove
Tenmile Creek
South Westerlo
Preston Hollow
700-800
HIGH KNOB
850
Medusa
ALBANY COUNTY
GREENE COUNTY
Cooksburg
Greenville
Basic Creek
Oak Hill
Durham
Norton Hill
Gilboa
Gilboa Dam
STEVENS MT
Conesville
Manor Kill
STEENBURG MT
850-950
850-1050
SOUTH MT
MT PISGAH
2912
Suprise
450-600
SICKLERS MT
PINE MT
Grand Gorge
3423
750-850
MT HAYDEN
East Durham
Freehold
898
Urlton
450-600
Gayhead
500-700
650-750
Huntersfield
Prattsville
Prattsville
1200
700-800
Batavia Kill
Windham
Windham
1560
500-700
PATTERSON RIDGE
MOSQUITO POINT
CAVE MT
Hensonville
450-600
Purling
400-500
South Cairo
Catskill Creek
POTIC MOUNTAIN
Leeds
350-450
Jewett
2505
700-800
Roandtop
550-650
450-600
700-850
East Kill
VLY MT
3529
Lexington
750-800
EAST JEWETT RANGE

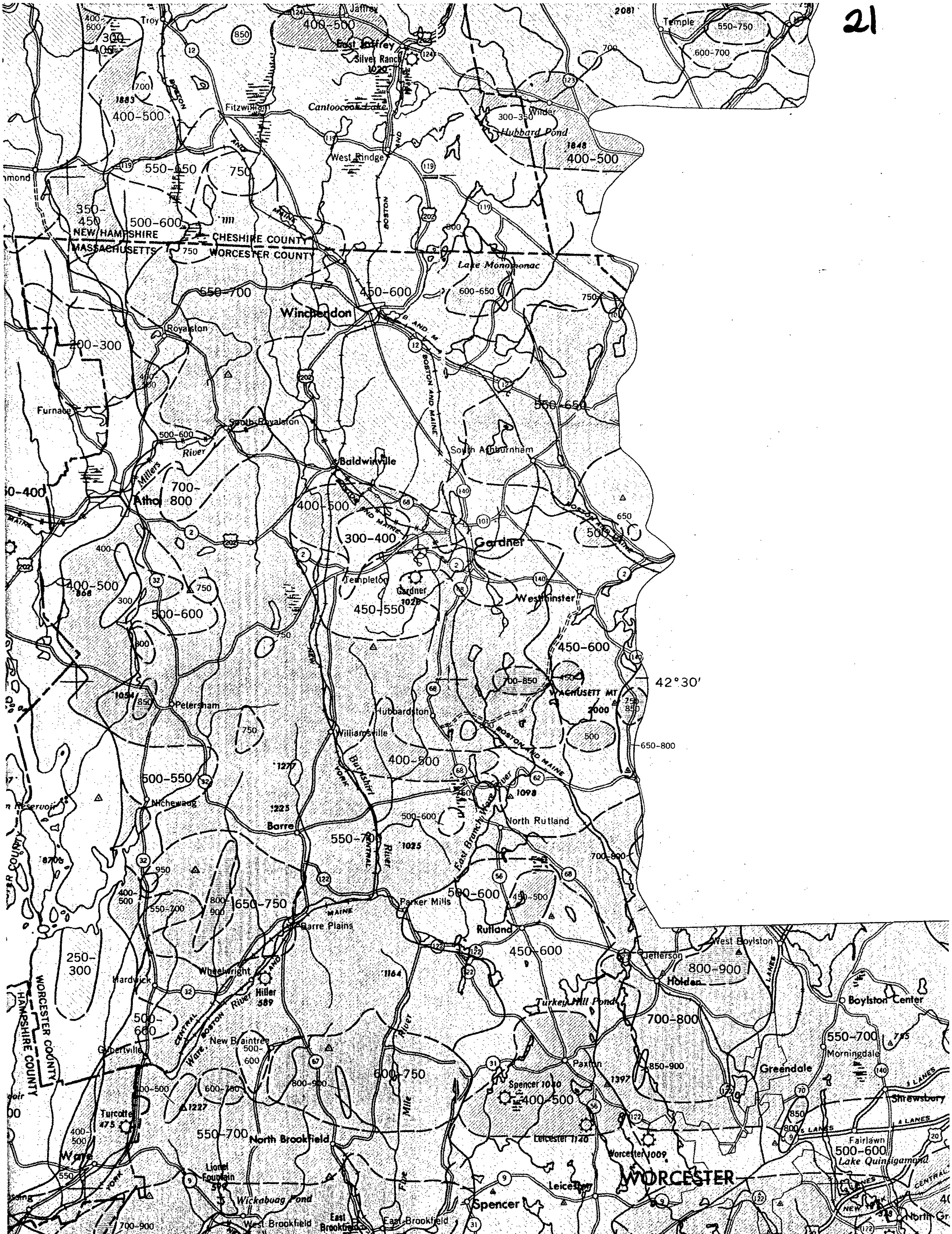
Schenectady
MOHAWK RIVER
Vischer Ferry
Niskayuna
Waterford
450-600
Cohoes Falls
Cohoes
Raymertown
450-550
Mt. Rafinesque
1197
1766
North Petersburg
Grafton
Cropseyville
NECTADY COUNTY
ALBANY COUNTY
Intercity
340
Maywood
250-400
362
Latham
Albany
282
Newtonville
Troy
Eagle Mills
450-550
350-500
1338
Rensselaer Reservoir
Guilderland
McKownville
350-500
ALBANY
Wynantskill
Poestenkill
600
East Poestenkill
Berlin
300-400
Voorheesville
Defreestville
446
West Sand Lake
Sandlake
New Scotland
Slingerlands
Elsmere
Salem
250
350-
450
Delmar
Unionville
Glenmont
East Greenbush
260
350-500
Sliters
Crooked Lake
Burden Lake
Cherryplain
Feura Bush
250-350
150-300
1743
West Stephentown
2249
South Albany
(Unverified)
400-500
Moordener
East Schodack
Hoag Corners
1655
Stephentown
300-400
Selkirk
South Bethlehem
Selkirk
160
300-400
450-600
Castleton on Hudson
Nassau
300-400
1140
East Nassau
350-
Ravena
180
Ravena
450-550
450-550
Brainard
RENSSELAER COUNTY
COLUMBIA COUNTY
1122
West Lebanon
450-600
Lebanon Springs
Alcove
North Chatham
400-500
New Baltimore
Old Chatham
West Pittsfield
350-
450
Farly's Airpark
10
850
850
Canaan
650
2060
Suprise
450-600
Kinderhook
East Chatham
Stuyvesant
Stuyvesant Brook
450-550
Chatham
350-500
500-600
Richmond
Urlton
Coxsackie
Kinderhook Creek
Kline-kill
880
Ghent
West Stockbridge
450-600
300-
400
Columbiaville
300-
450
257
Spencertown
Austerlitz
2065
400
POTIC MOUNTAIN
450-600
South Cairo
Stottville
450-550
Claverack
NEW YORK
MASSACHUSETTS
650
450-
500
550-
700
1930
Leeds
Athens
350-450
400-
450
710
Green River
Housatonic
600
400-500
Hudson
Philmont
400-500
550-650
500-650
North Hillsdale
400-
500
800
700


North Petersburg
North Pownel
Pownal
Bald Mountain
2693
Petersburg
Hoosic River
Little Hoosic
250-400
100-250
2754
3089
Hartwellville
Whitingham Reservoir
300-400
Jacksonville
Whitingham
Readsboro
2222
Stamford
3014
2459
BENNINGTON COUNTY
WINDHAM COUNTY
BENNINGTON COUNTY
BERKSHIRE COUNTY
VERMONT
MASSACHUSETTS
350-450
500-650
300-400
400-500
550
250-400
Williamstown
North Adams
RENSSELAER COUNTY
BERKSHIRE COUNTY
2047
400-500
Berlin
500-600
200-350
Stevens 690
500-600
350-500
500-600
2034
North Heath
650
HOOSAC TUNNEL
Hoosac Tunnel
1726
Fair View Farm 954
200-300
450-600
ADAMS MOUNTAIN
South Williamstown
NOT SURVEYED
Mt Greylock
Florida
Deerfield River
Cold River
1961
200-300
400-500
400-55
400-550
Cherryplain
400-500
250-400
300-400
Charlemont
Adams
500-600
350-500
2653
300-400
150-300
400
100-250
Adams 1400
100-200
400-500
250-400
BERKSHIRE COUNTY
FRANKLIN COUNTY
1845
2249
Savoy
Stephentown
Hancock
Cheshire
Cheshire 970
450-600
Cheshire Reservoir
400-500
300
200-300
200-300
2167
Plainfield
200-300
Ashfield
350-500
Lanesboro
Berkshire
Windsor
Pontoosuc Lake 1100
500-700
Pontoosuc Lake
2186
West Cummington
450-600
Lebanon Springs
Lake Onota
Coltsville
Dalton 1200
2145
FRANKLIN COUNTY
HAMPSHIRE COUNTY
250-400
Pittsfield
West Pittsfield
Pittsfield 1170
2135
Hinsdale
650
BERKSHIRE COUNTY
HAMPSHIRE COUNTY
300-400
Cummington
Goshen
1438
250-400
2060
500-600
600
300-400
2295
300
Worthington Corners
Chesterfield
350
Richmond
Washington
Lenox
Middle
Westfield River
Dead Branch
600-700
250-300
350-500
Stockbridge Bowl
Middlefield
South Worthington
750
West Stockbridge
600
650
500-600
Becket
1725
Westfield
450-600
Little River
400
Lee
2272
500-600
650
300-400
1354
Knightville
Stockbridge
550-700
600-750
West Becket
Housatonic
700-800
800
450-550
700
Tyringham
650
450-550
1797
900
1228
550-650
Mt Wilcox
Huntington

20



Brattleboro-Hinsdale
360
Hinesburg
CHESHIRE COUNTY
WINDHAM COUNTY
150-300
100-250
450-550
300-400
400
550
Hinsdale
500-600
Ashuelot River
Winchester Airpark
460
Winchester
350-500
NEW HAMPSHIRE
VERMONT
Vernon
Richmond
South Halifax
WINDHAM COUNTY
FRANKLIN COUNTY
250-400
CHESHIRE COUNTY
FRANKLIN COUNTY
North Bernardston
550-700
500-600
East Northfield
250-400
North Heath
650
600
North River
Mt Grace
300-450
Mount Hermon
200-300
Warwick
Colrain
Bernardston
1254
MOUNTAIN
400-550
400-500
1872
300
400
200-300
Crag Mt
200
250
200-300
Falls
500-700
Furnace
1588
400-500
Shelburne Falls
Greenfield
400-550
Erving
400-500
Turners Falls
350
250-400
Orange
Shelburne
200-300
200
400
Millers Falls
Millers
300-400
Orange
(555)
350-450
450-550
400-500
300-400
Deerfield
POCUMTUCK RANGE
CONNECTICUT
Wendell
852
400-500
Deerfield River
Montague 450-600
Ashfield
1225
1345
450-600
Conway
450-550
Lock Village
New Salem
Mill
1219
350-500
Mt Toby
1275
1260
FRANKLIN COUNTY
HAMPSHIRE COUNTY
South Deerfield
Shutesbury
300
200-
300
Goshen
300
West Whatley
250-300
East Whatley
250-400
Quabbin Reservoir
250-400
500-
600
1649
Pilgrim
126
North Amherst
400-
500
FRANKLIN COUNTY
WORCESTER COUNTY
Chesterfield
400-
500
Pelham
Williamsburg
450-550
North Hadley
Amherst
Hatfield
1238
Leeds
250-
300
WORCESTER COUNTY
HAMPSHIRE COUNTY
Hadley
Fort River
350-500
Arel
100
Norwottuck
400-
550
Northampton
La Fleur
120
500-
600
878
1115
599
Atwood
116
Quabbin Reservoir
Loudville
Bachelor Brook
450-550
300-450
250-400
Belchertown
Turcott
475
South Hadley
Ware
250-
350
100
Easthampton
South Hadley
Holyoke
90
Granby
780
650
Gibbs Crossing
Mt Tom
1202
300-
400
Southampton
HAMPSHIRE COUNTY
Metropolitan



Jaffrey
East Jaffrey
Silver Ranch
Troy
Temple
Fitzwilliam
Cantoocook Lake
Wilder
Hubbard Pond
West Rindge
NEW HAMPSHIRE
MASSACHUSETTS
CHESHIRE COUNTY
WORCESTER COUNTY
Lake Monomonac
Winchendon
Royalston
Furnace
South Royalston
Millers River
Baldwinville
South Ashburnham
Athol
Gardner
Templeton
Westminster
WACHUSETT MT
Petersham
Hubbardston
Williamsville
Nichewaug
Barre
North Rutland
Parker Mills
Rutland
Barre Plains
Wheelwright
Hardwick
Hiller
Gilbertville
New Braintree
Turkey Hill Pond
Holden
Jefferson
West Boylston
Boylston Center
Morningdale
Greendale
Paxton
Spencer
North Brookfield
Leicester
Worcester
WORCESTER
Shrewsbury
Fairlawn
Lake Quinsigamond
Turcotte
Ware
Lionel Fountain
Wickaboag Pond
West Brookfield
East Brookfield
North Gr
WORCESTER COUNTY
HAMPSHIRE COUNTY
BOSTON AND MAINE
42°30′
400-500
550-750
600-700
300-350
550-650
750
350-450
500-600
550-700
450-600
600-650
200-300
700-800
400-500
300-400
450-550
500-550
550-700
650-750
800-900
250-300
500-600
600-750
400-500
550-700
700-900
800-900
850-900
700-800
500-600
650-800
700-850

The radioactivity data was obtained with scintillation detection equipment (Davis and Reinhardt, 1957) installed in a twin-engine aircraft. Parallel flight traverses were oriented east-west except in the area west of Albany, N. Y., where they were oriented north-south, and flown at one-mile intervals at a nominal elevation of 500 feet above the ground. The radioactivity data were compensated for deviations from the surveying elevation, and for the cosmic-ray component. The flight path of the aircraft was recorded by a gyrostabilized continuous-strip-film camera.

The effective area of response of the scintillation equipment at an elevation of 500 feet is a circle approximately 1,000 feet in diameter, and the radioactivity recorded is an average of the radioactivity received from within the area. The scintillation equipment accepts only pulses originating from gamma radiation with energies greater than 50 kev (thousand electron volts). A cesium-137 source is used during periodic calibrations to assure uniformity of equipment response.

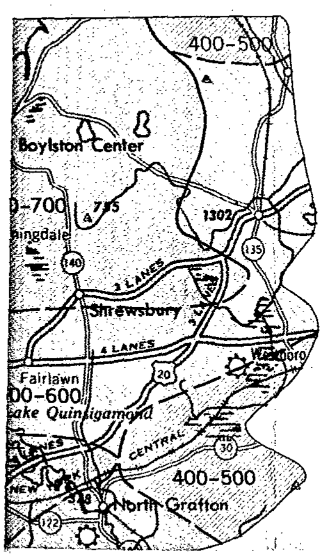
The gamma radiation at 500 feet above the ground has three principal sources: cosmic radiation, radionuclides in the air (mostly radon daughter products), and radionuclides in the surficial layer of the ground. The cosmic component is determined twice daily by calibrations at 2,000 feet above the ground and is removed from the radioactivity data.

The component due to radionuclides in the air at 500 feet above the ground is difficult to evaluate. It is affected by meteorological conditions, and a tenfold change in radon concentrations is not unusual under conditions of extreme temperature inversion. However, if inversion conditions are avoided, the air component may be considered to be fairly uniform on a given day in a particular area, and will not affect the discrimination of the radioactivity levels that reflect changes in the ground component.

The ground component comes from the upper few inches of the ground. It consists of gamma rays from natural radionuclides, principally members of the uranium and thorium radioactive decay series and potassium-40, and fallout from radioactive nuclear fission products. Locally the amount of fallout must be small as the lowest total radiation measured over several areas in New York and New England was less than 100 counts per second in areas not affected by absorption of gamma energy by water. The distribution of fallout in the area surveyed is assumed to be uniform.

In compiling the radioactivity data, all radioactivity lows attributable to bodies of water were deleted to facilitate the reading of the map. The aeroradioactivity profiles were examined and significant changes or breaks in level were correlated from profile to profile. The changes were then plotted on overlays of the base maps and connected by solid or dashed lines depending on the degree or correlation. The areas between the lines of change were assigned general ranges of radioactivity level by scanning the records obtained over these specific areas.

Davis, F. J., and Reinhardt, P. W., 1957, Instrumentation in aircraft for radiation measurements: Nuclear Sci. and Eng., v. 2, no. 6, p. 713-727.



EXPLANATION

300-400

Radioactivity boundary

Solid where well defined, dashed where transitional or not well defined. Numbers indicate general range of radioactivity levels in counts per second

900-1150 | 750-900 | 650-800 | 550-700

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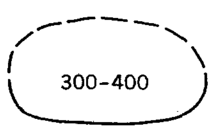
extreme temperature inversion. However, if inversion conditions are avoided, the air component may be considered to be fairly uniform on a given day in a particular area, and will not affect the discrimination of the radioactivity levels that reflect changes in the ground component.

The ground component comes from the upper few inches of the ground. It consists of gamma rays from natural radionuclides, principally members of the uranium and thorium radioactive decay series and potassium-40, and fallout from radioactive nuclear fission products. Locally the amount of fallout must be small as the lowest total radiation measured over several areas in New York and New England was less than 100 counts per second in areas not affected by absorption of gamma energy by water. The distribution of fallout in the area surveyed is assumed to be uniform.

In compiling the radioactivity data, all radioactivity lows attributable to bodies of water were deleted to facilitate the reading of the map. The aeroradioactivity profiles were examined and significant changes or breaks in level were correlated from profile to profile. The changes were then plotted on overlays of the base maps and connected by solid or dashed lines depending on the degree or correlation. The areas between the lines of change were assigned general ranges of radioactivity level by scanning the records obtained over these specific areas.

Davis, F. J., and Reinhardt, P. W., 1957, Instrumentation in aircraft for radiation measurements: Nuclear Sci. and Eng., v. 2, no. 6, p. 713-727.

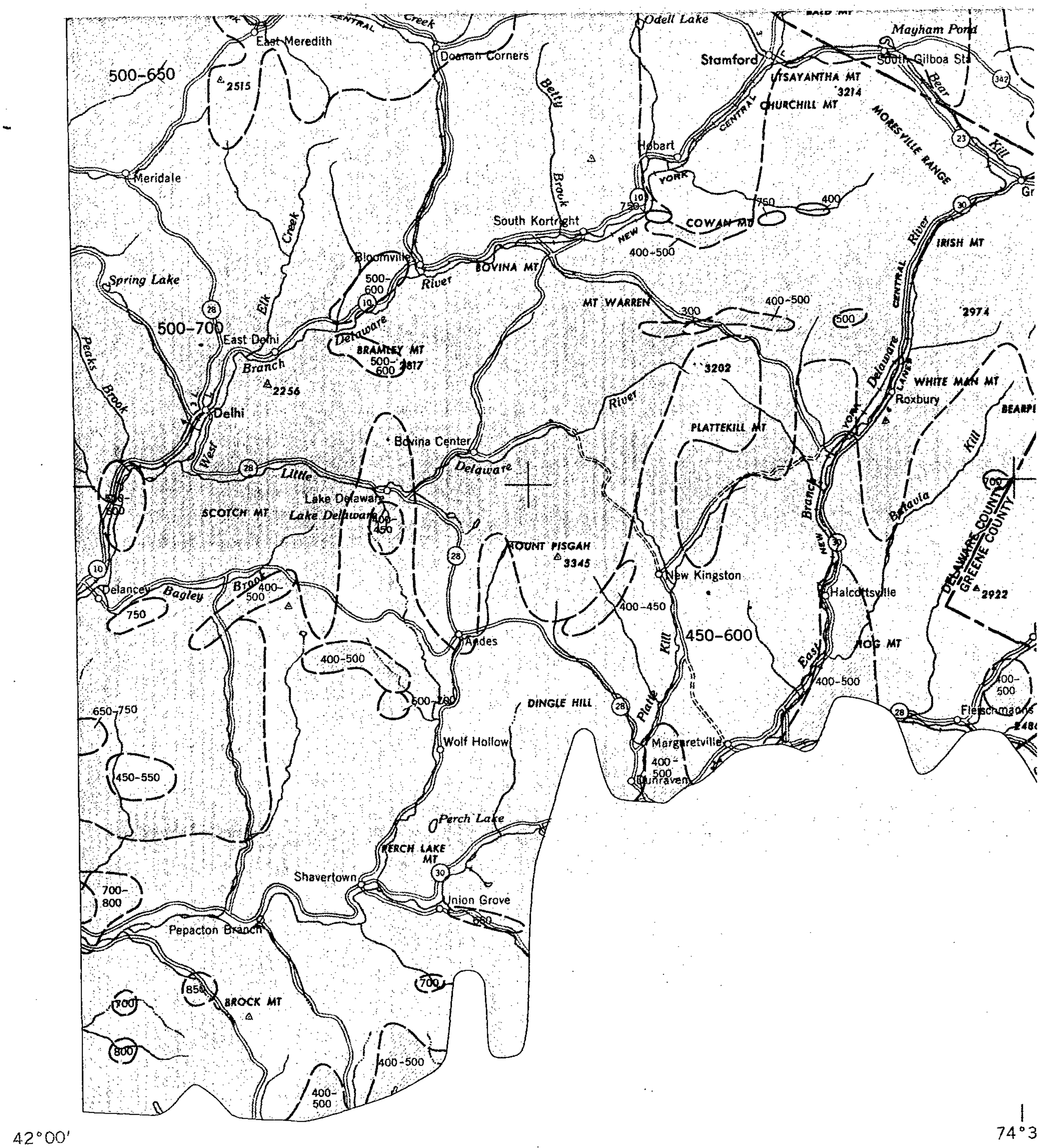
EXPLANATION



Radioactivity boundary

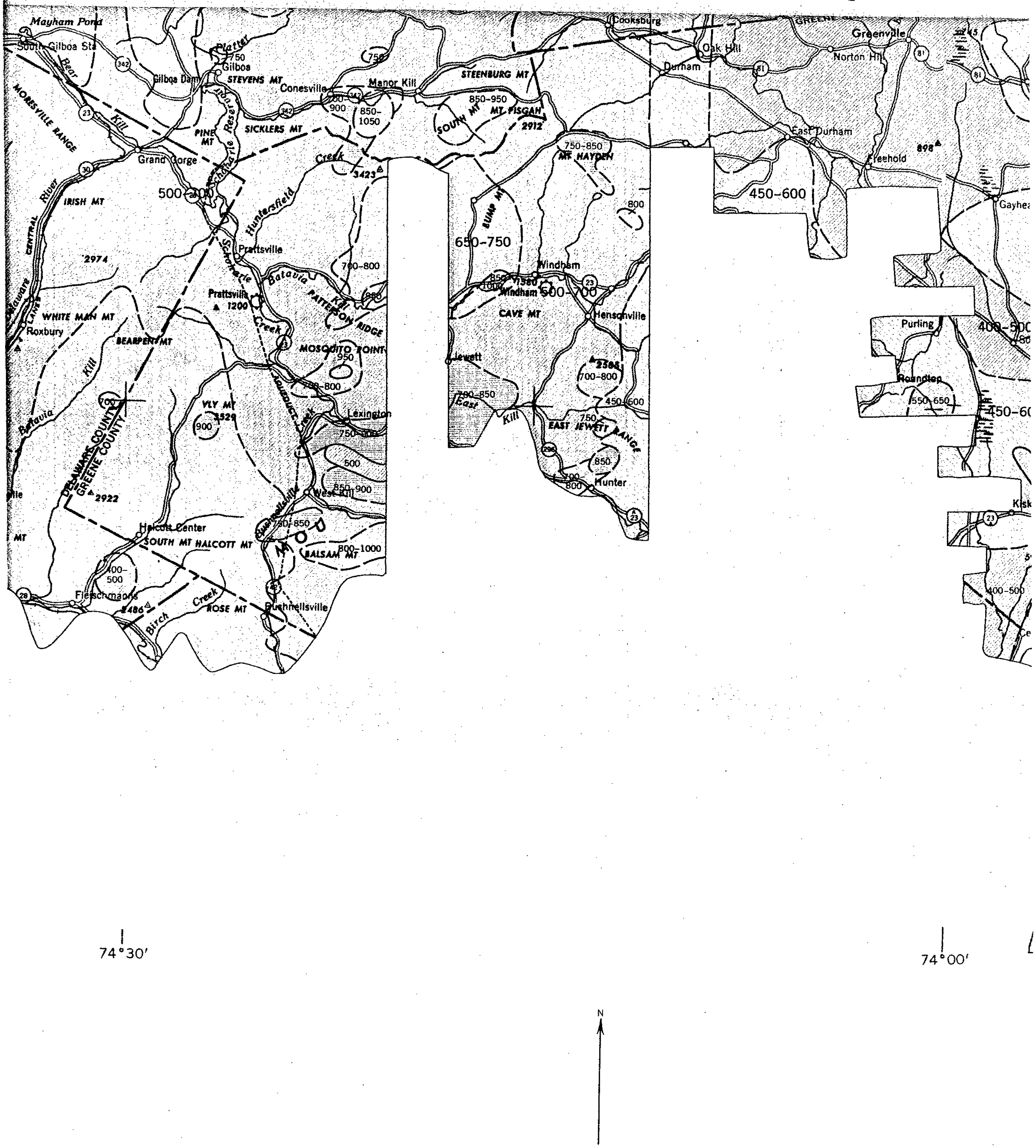
d, dashed where transitional or not well defined.
neral range of radioactivity levels in counts per

)0 | 650-800 | 550-700



Base from U.S. Geological Survey 250,000 series quadrangles: Utica, 1944; Binghamton, 1944; Glen Falls, 1944; Albany, 1947; Portland, 1942; and Boston, 1947

GEOPHYSICAL INVESTIGATIONS
MAP GP-358
AEC-CEX-59.4.14



MAGNETIC NORTH DEVIATES
FROM 11°45′W TO 17°30′W
WITHIN MAP AREA

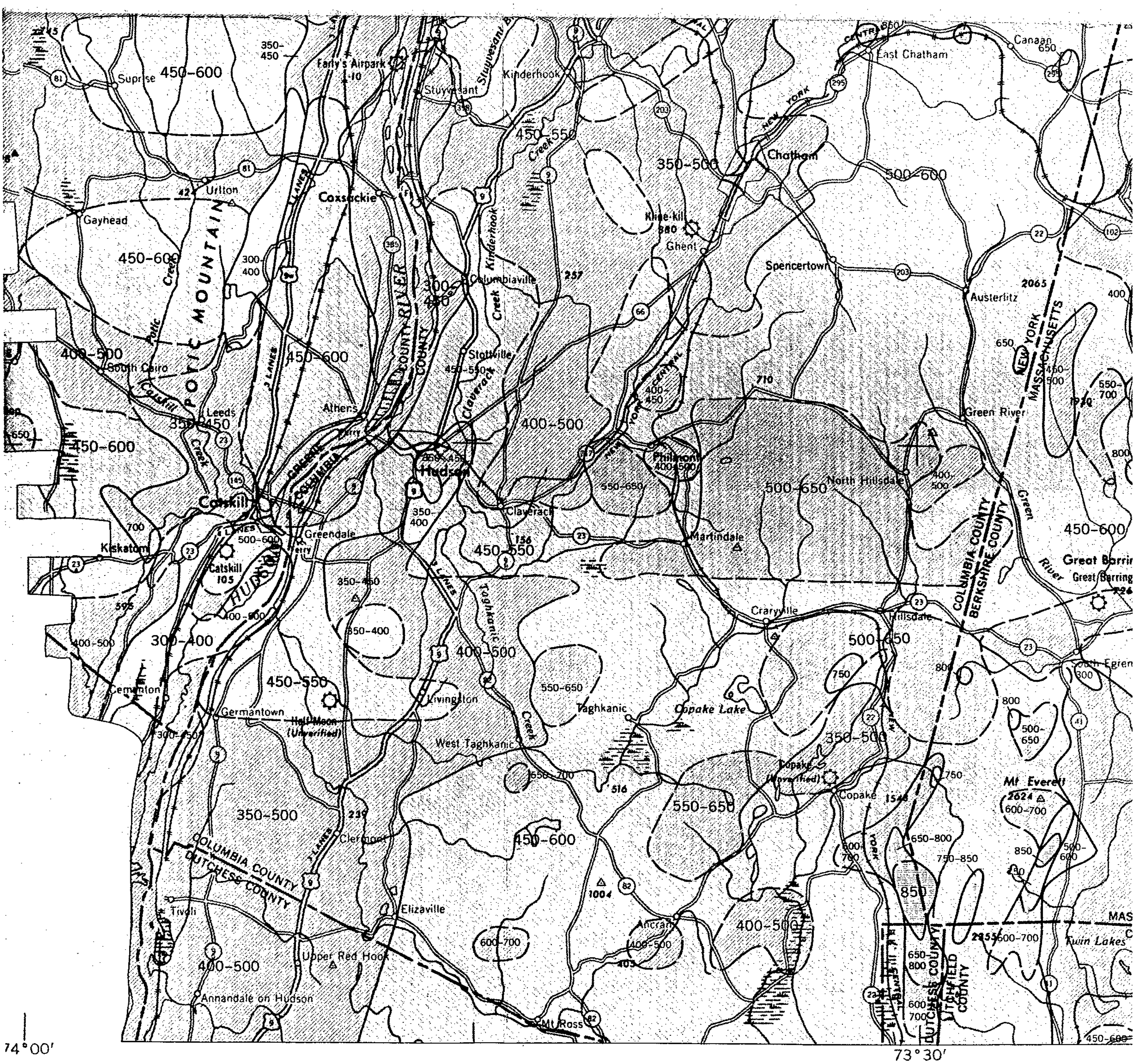


PLATE 1 AERORADIOACTIVITY (

[VITY OF PARTS OF EAST-CENTRAL NEW Y

By

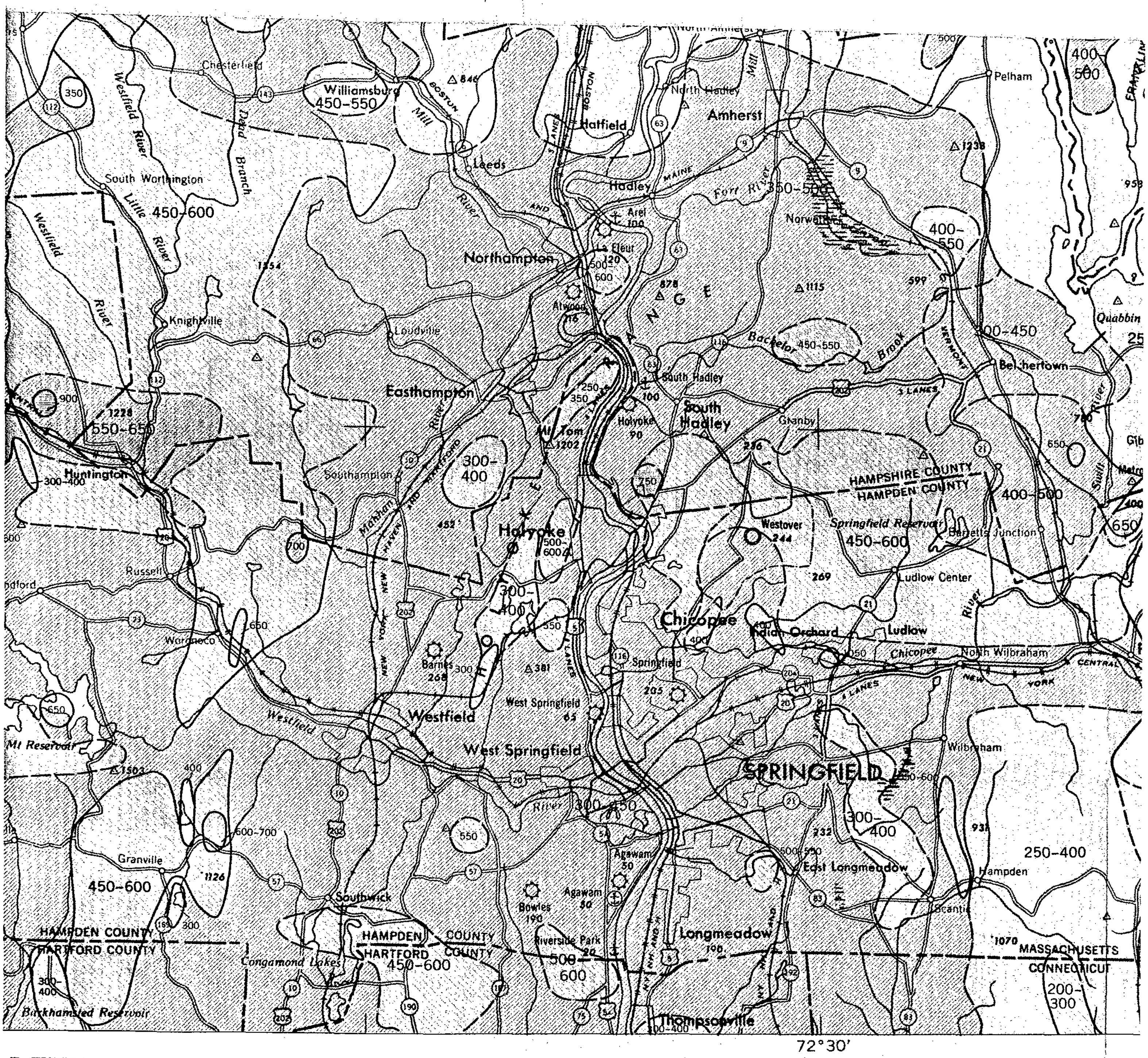
Peter Popenoe

SCALE 1:250 000

5 0 5 10 15

5 0 5 10 15 20 25

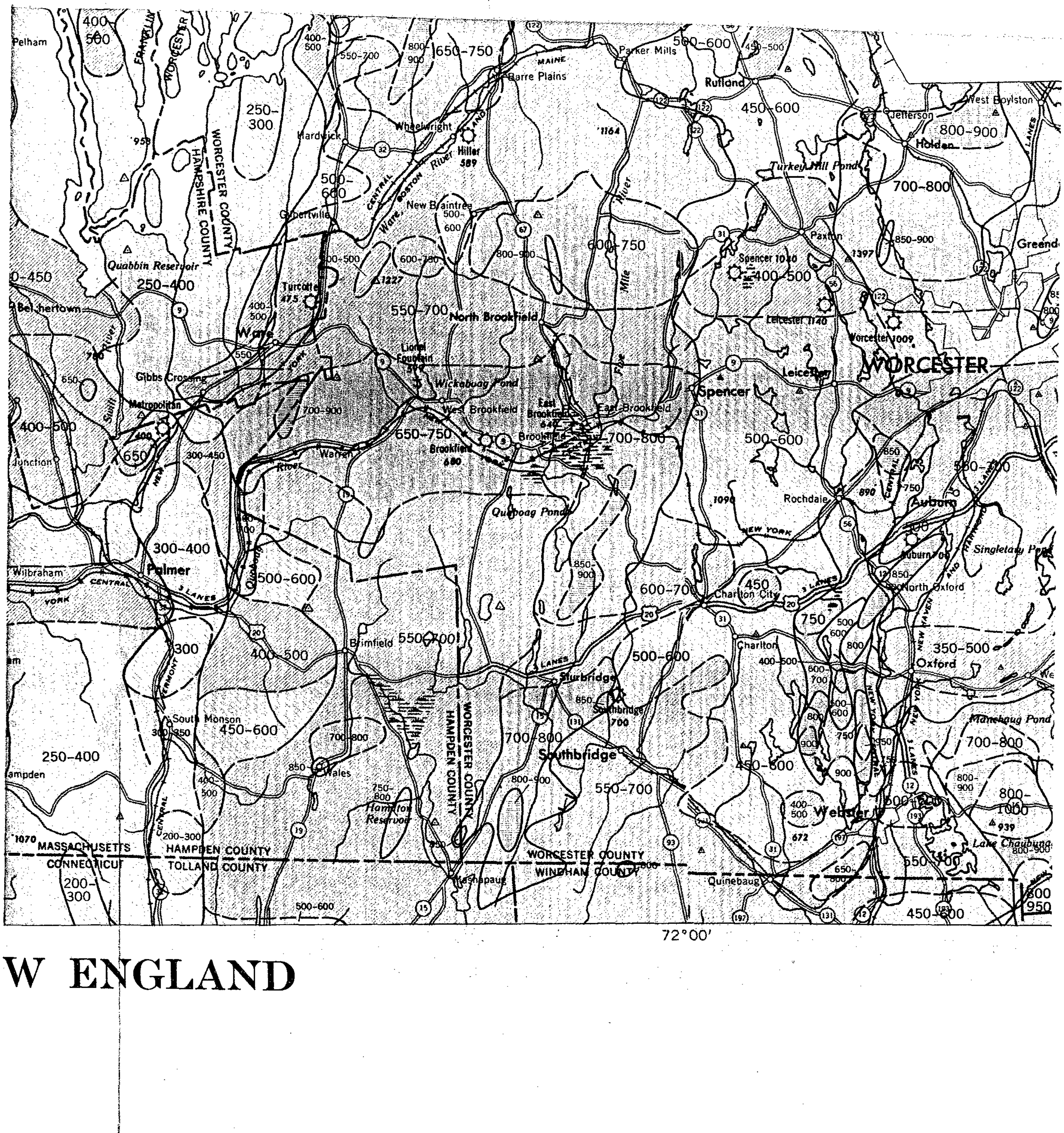
1964



NEW YORK AND WEST-CENTRAL NEW EN(

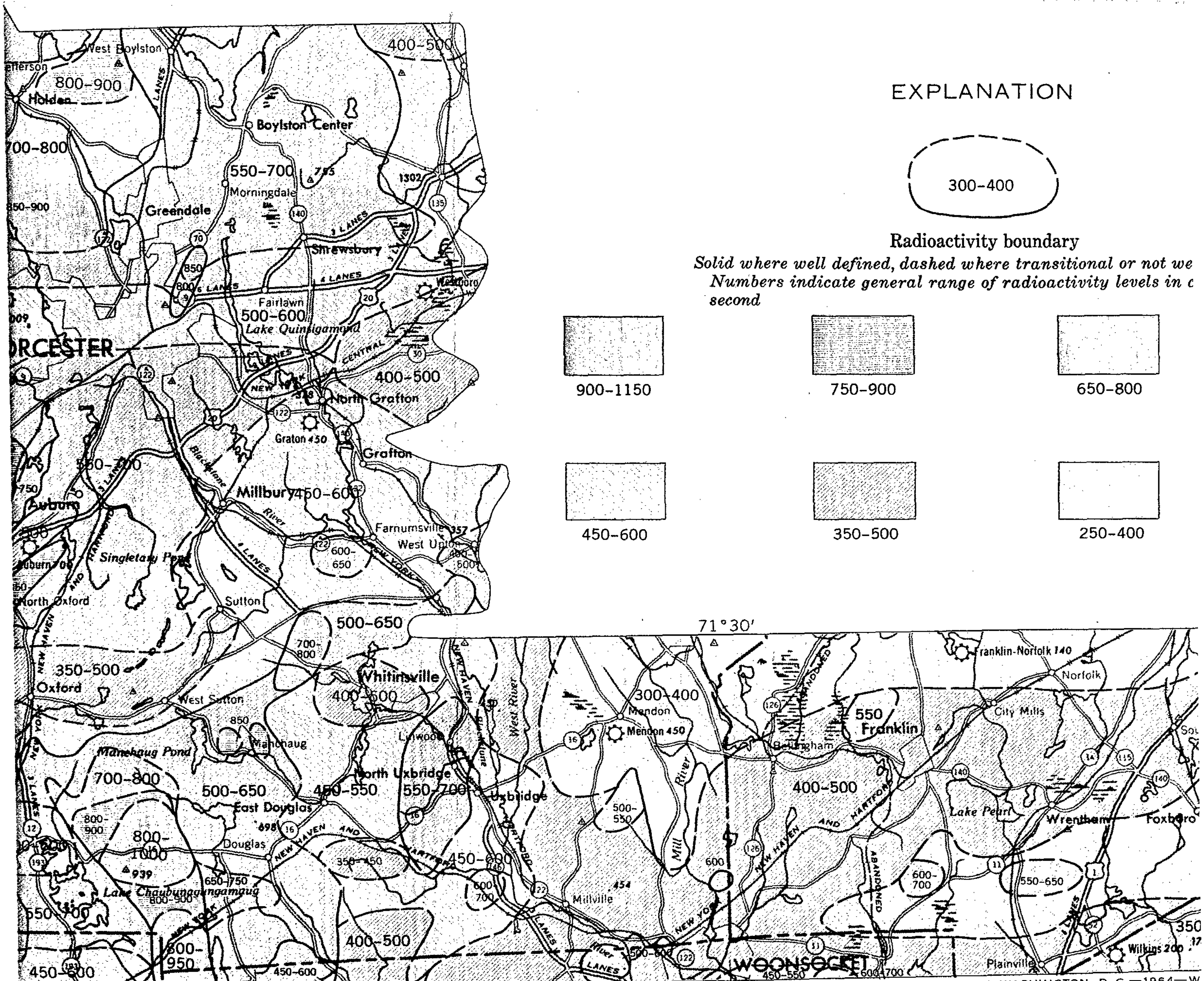
15 20 25 MILES

20 25 KILOMETERS



Pelham
Quabbin Reservoir
WORCESTER COUNTY
HAMPSHIRE COUNTY
Barre Plains
Parker Mills
Rutland
West Boylston
Jefferson
Holden
Hardwick
Wheelwright
Hiller 589
Turkey Hill Pond
Gilbertville
New Braintree
Paxton
Greendale
Spencer 1040
Belchertown
Turcotte 475
Ware
North Brookfield
Leicester 1140
Worcester 1009
Gibbs Crossing
Lionel Fountain 599
Wickaboag Pond
WORCESTER
Metropolitan
West Brookfield
East Brookfield
Spencer
Leicester
Junction
Warren
Brookfield 680
Rochdale
Auburn
Quaboag Pond
Singletary Pond
Wilbraham
Palmer
Charlton City
North Oxford
Brimfield
Charlton
Oxford
Sturbridge
Southbridge 700
South Monson
Manchaug Pond
Southbridge
Wales
Hamilton Reservoir
Webster
Lake Chaubunagungamaug
MASSACHUSETTS
CONNECTICUT
HAMPDEN COUNTY
TOLLAND COUNTY
WORCESTER COUNTY
WINDHAM COUNTY
Mashapaug
Quinebaug
72°00'

W ENGLAND



EXPLANATION

300-400

Radioactivity boundary

Solid where well defined, dashed where transitional or not we
Numbers indicate general range of radioactivity levels in c
second

900-1150 750-900 650-800

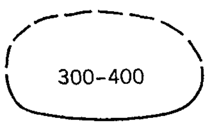
450-600 350-500 250-400

71°30′ INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1964—W

Aerora
above
of P. F

Map obtainable from U.S. Geolog
pric

EXPLANATION



Radioactivity boundary

·here well defined, dashed where transitional or not well defined. bers indicate general range of radioactivity levels in counts per d

750-900

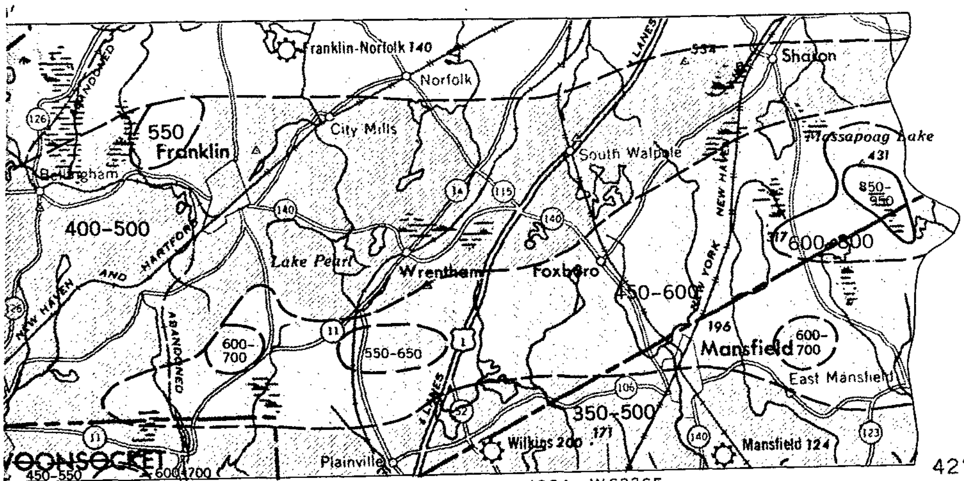
650-800

550-700

350-500

250-400

50-300



INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1964—W63265

Aeroradioactivity survey made at 500 feet above the ground under the direction of P. Popenoe and others, 1958–60

Map obtainable from U.S. Geological Survey, Washington, D.C. 20242
price 75 cents